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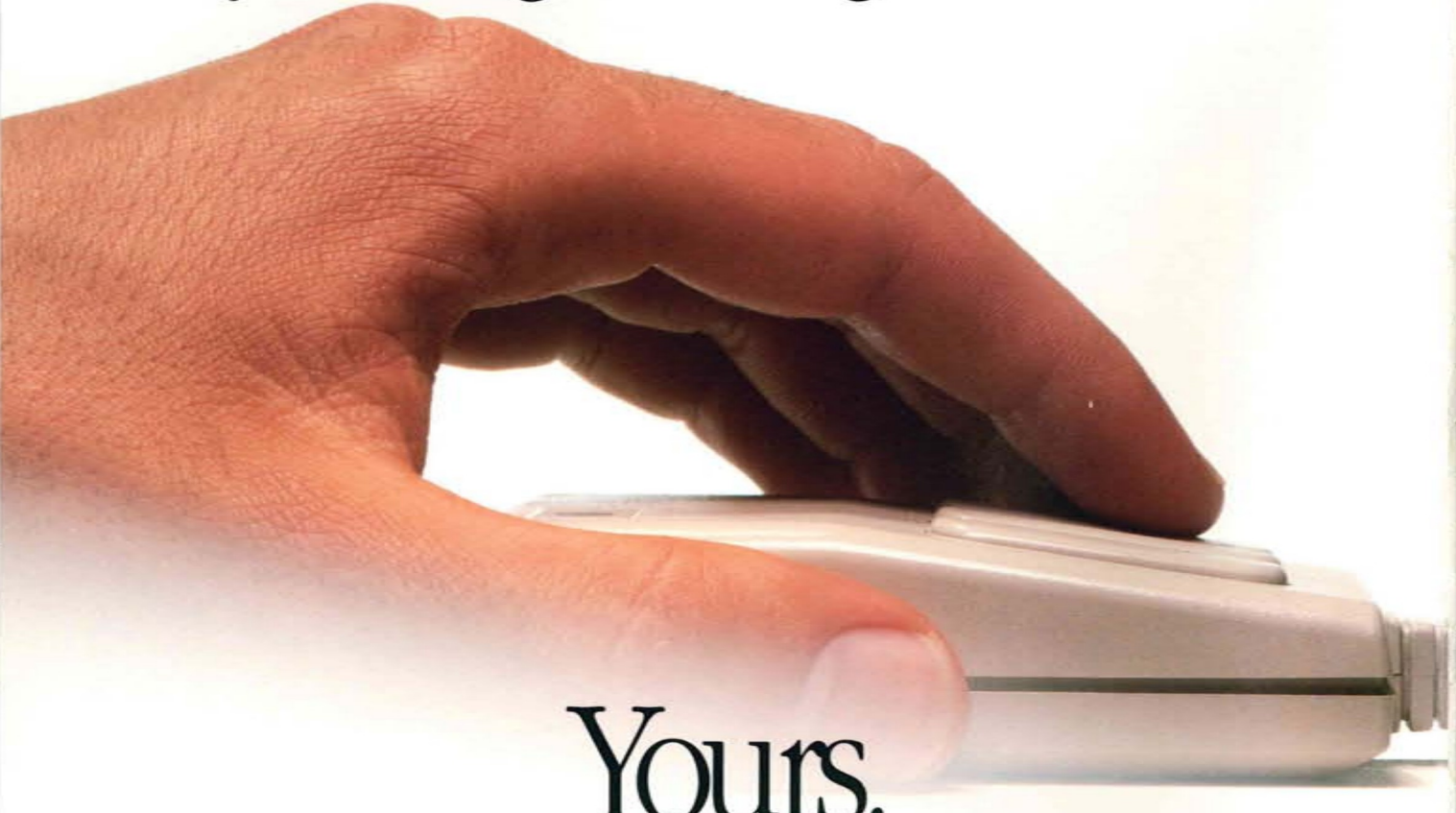


SCIENTIFIC ANALYSIS AND VISUALIZATION OF THE ENVIRONMENT

IRIS INDIGO FAMILY: ELAN GRAPHICS

IRIS CRIMSON

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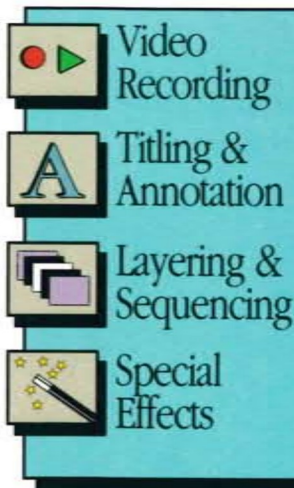
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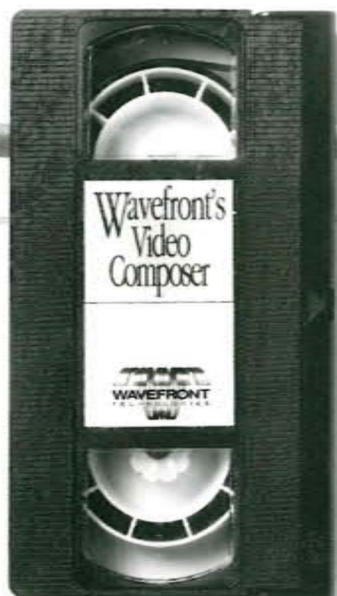
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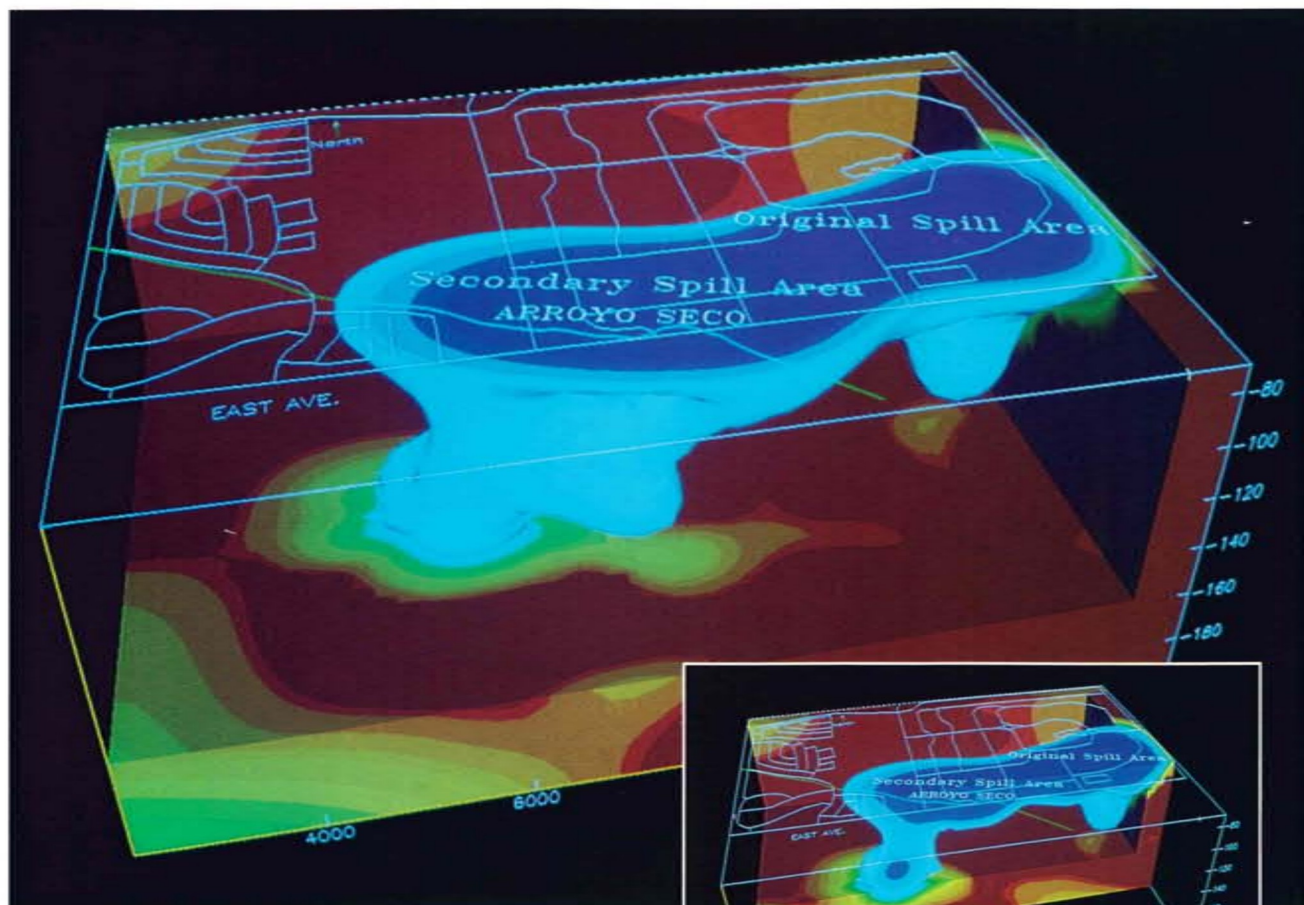
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the plume, shows various levels of PCE contamination within the plume itself.

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DYNAMIC GRAPHICS, INC.
Alameda / Denver / Houston / Washington, D.C. / London

Headquarters
Dynamic Graphics, Inc.
1015 Atlantic Avenue
Alameda, CA 94501
Phone: 510-522-0700
Fax: 510-522-5670

Regional Offices
Denver
303-694-6011
Houston
713-952-2611
Washington, D.C.
301-656-3060

International Office
Dynamic Graphics Limited
Addison-Wesley Building
Finchampstead Road
Wokingham, Berkshire RG11 2NZ
United Kingdom
Phone: 44-734-774755
Fax: 44-734-774721

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THE MAGAZINE OF VISUAL COMPUTING

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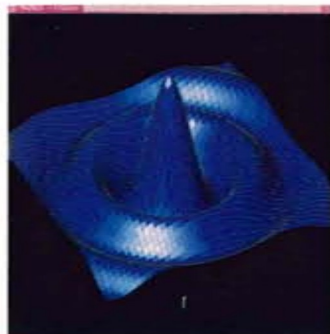
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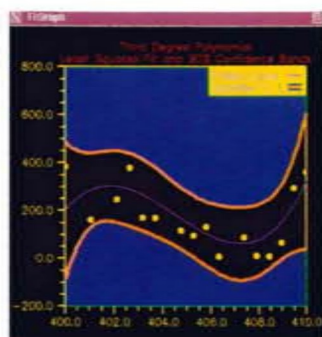
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Editor	Anne-Marie Gambelin
Contributing Editor (International)	Crispin Littlehales
Department Editor	Gaye Graves
Editorial Consultants	Douglas Cruickshank Mark Compton
Design	Frank X. Doyle Beth Marx
Digital Images	Susan Moran Doug Morgan
Typesetting	Lauren Langford Typography
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EDITOR'S NOTE

It is awkward, initially, to categorize the Earth and the environmental research associated with it as a marketplace. Odd as it may seem, though, considering the Earth as an environmental research marketplace allows us to view it as a place where goods are traded, ideas are exchanged and competition is fostered. Predicated as such, this perspective defines what is required for us to understand, direct, trade, design, and endeavor for the Earth and its future.

To respond to a multitude of environmental issues, Silicon Graphics has initiated an Earth and Space Sciences Working Group, chaired by Silicon Graphics' Vice President of Applications and Business Development. This group forms an operational umbrella under which Silicon Graphics' array of environmental programs that embrace the spirit of Silicon Graphics' commitment to the environment reside, representing the multiple facets of the environmental research marketplace.

Silicon Graphics' evangelical environmental efforts are reflected in account management and support of leading companies involved in the environmental research marketplace. The results of Silicon Graphics' Earth and Environmental Science endeavors are image processing systems and tools designed specifically to allow scientists to monitor and analyze the profusion of digital data gathered by satellites. Through the Global Change Research program, Silicon Graphics hopes to affect major Earth and space programs, both government and industry funded. For the Geographic Information Systems market segment, specific software partners and tools are made available for research of the multiple environmental data models. Supplementing our Earth and Environmental Science, Global Change Research, and Geographic Information Systems foci is the S.A.V.E. program, which is responsible for the education, enlightenment, and enlistment of the scientist and the layperson for Scientific Analysis and Visualization of the Environment — indeed, to benefit the Earth and ensure its future.

We invite you to join us in guiding our efforts toward a better future for the Earth for generations to come.

— Editor

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IRIS Indigo

F A M I L Y

By Carl Furry

*Just six months after unveiling the world's first RISC PC, Silicon Graphics grows the IRIS Indigo™ family by four members — with a graphics powerhouse named **CLAN** heading it up.*

When Michael Zeitlin first got his hands on an IRIS Indigo™ RISC PC, the head of Texaco's Integrated Visualization Technology Team had only one complaint. While he loved the machine — he even planned to buy one for home use — Zeitlin said Texaco's intense number-crunching and data visualization applications required something more from the revolutionary desktop computer. "We could really use a stronger graphics offering," noted the oil giant's resident evangelist for visual computing. Among the features the base model lacked, Zeitlin listed faster rendering and 24-bit color.

Only six months after Silicon Graphics wheeled out the computing industry's first RISC-based personal computer, Mike Zeitlin got his wish. On January 28, 1992, the

company unveiled four additions to the IRIS Indigo family — including two systems that feature faster, 24-bit graphics. The new systems — IRIS Indigo XS™, IRIS Indigo XS24™, IRIS Indigo Elan™ and a dual-monitor version — bring to the IRIS Indigo family graphics performance that, prior to the January introduction, was available only on the company's costlier computers. The new family members retain the original IRIS Indigo's space-friendly footprint: 8½-by-11 inches, the size of a standard sheet of paper.

Gradual Evolution

Implementing up to four varying configurations of Silicon Graphics' patented Geometry Engine™, the new systems are priced from \$13,000 to \$27,000, promoting the family's graphics capabilities to rank as the most powerful on the desktop today. Among the features introduced to the IRIS Indigo line are true 24-bit color, workstation-class resolution, a 72Hz refresh rate and FDDI connectivity. The new packages are aimed at a wide range of user environments, from CAD/CAM, CASE and publishing for the IRIS Indigo XS and IRIS Indigo XS 24, to molecular modeling and earth sciences for the IRIS Indigo Elan and "dual-headed" IRIS Indigo.

The new systems offer a gradual evolution from virtual 24-bit color to fully featured, POWER Series™ GTX-level graphics performance. For a list price of \$13,000, users can purchase IRIS Indigo XS, a virtual 24-bit (8-bit frame buffer) system with 1280x1024 support, 60Hz or 72Hz refresh rate and an optional z-buffer. The system includes a 16-inch color monitor and comes with a keyboard, mouse and 16Mb of memory, and Silicon Graphics Personal IRIS™ users will notice that the new desktop system delivers the same graphics performance as their deskside Personal IRIS Turbo Graphics boxes.

Also new to the family is the IRIS Indigo XS24, the first 24-bit, true-color IRIS Indigo — a machine stocked with an optional z-buffer, supporting 1280x1024 resolution and 60Hz or 72Hz refresh rates. The system also has the same graphics features as Sili-

con Graphics' high-end POWER Series systems with performance equal to currently available Personal IRIS Turbo Graphics computers. Priced at \$15,000, the IRIS Indigo XS24 includes a 16-inch color monitor, keyboard and mouse, as well as 16Mb of memory. For \$2,000, users can purchase the optional z-buffer.

Ranking as the most powerful graphics computer on the desktop today is the IRIS Indigo Elan, priced at \$27,000. Capable of generating one million 3D vectors per second, 225,000 3D triangles per second and 100,000 3D quads per second, the IRIS Indigo Elan churns out the same performance as Silicon Graphics' POWER Series GTX computers. In addition to 24-bit color and 24-bit z-buffering, the system has features never before found on a desktop system: texturing, transparency and atmospheric effects needed for real-time motion and interactive realism. For the price, users receive GTX graphics performance, a 19-inch color monitor, a keyboard and mouse and 16Mb of memory.

For Earth sciences and color publishing user environments, Silicon Graphics also engineered the dual-headed IRIS Indigo, a base system configured with two 16-inch color monitors, a keyboard and mouse and 16Mb of memory, for \$15,000.

Silicon Graphics engineers have also made the family entirely expandable. Upgrades are available from bottom to top. For instance, \$2,000 will bump users up from an IRIS Indigo XS to an IRIS Indigo XS24. And, a jump from the base-configuration IRIS Indigo to the top-of-the-line IRIS Indigo Elan runs \$16,000.

Clear Intentions

Designers of the IRIS Indigo family say they always intended to squeeze high-end workstation graphics into Silicon Graphics' affordable RISC PC package. "Many of the same things that are evident in the Elan were featured in the PI, but they have been pushed to the next level," said Marc Hannah, vice president and chief scientist for Silicon Graphics' Entry Systems Division. Taking their lead from the com-

pany's Advanced Systems Division — the product design arm credited with the company's status as a pioneer in computer graphics — Hannah, and ESD Director of Graphics Engineering, Chandler Harrell tinkered with numerous avenues by which a small-footprint, desktop system could crank out visual computing performance worthy of the Silicon Graphics' brand.

The eventual result was a new graphics technology that, according to Silicon Graphics engineers, signifies the latest breakthrough in fast, realistic graphics for desktop systems. With most graphics functions returned to graphics-specific hardware (visual processing moved to the CPU to lower the cost of the original IRIS Indigo), the new architecture could embrace more performance features than most people thought possible. Elan graphics features, along with those already listed, include:

- four stencil bitplanes
- four overlay and four window clipping ID planes
- thirty-two simultaneous window modules
- NTSC and PAL unencoded video output timings
- genlock capability
- stereo viewer control
- slot for live video I/O option card
- subpixel positioning
- advanced lighting models, such as Phong lighting, spotlights, local and infinite light source positioning and two-sided lighting
- anti-aliased lines and points
- high-speed graphics DMA
- pan and zoom capabilities
- atmospheric effects
- texture mapping
- Non-Uniform Rational B-Spline surfaces.

The heart of the Elan Graphics subsystem contains twenty-five custom VLSI chips based on seven new custom VLSI designs. These chips contain a total of 700,000 custom gates, giving Elan Graphics a fifteen-fold increase in the level of integration over Silicon Graphics' previous graphics

Silicon Graphics' IRIS Indigo Family Specs

Feature	IRIS Indigo	IRIS Indigo XS	IRIS Indigo XS24	IRIS Indigo Elan
Screen Resolution	1024x768	1280x1024	1280x1024	1280x1024
Color Planes	8	8	24	24
Virtual 24-bit Color	Yes	Yes	N/A	N/A
Z-Buffer	Software	Option	Option	Yes
3D Vectors Per Second	231,000	250,000	250,000	1 Million
3D Polygons Per Second	14,000	60,000	60,000	225,000
3D Quads Per Second	6,600	25,000	25,000	100,000
2D Vectors Per Second	451,000	250,000	250,000	1 Million
SPECmarks	26	26	26	26
System Software	IRIX	IRIX	IRIX	IRIX
Price	\$9,500*	\$13,000*	\$15,000*	\$27,000**
Availability	Now	March	March	March

*16Mb, 16-inch monitor

**16Mb, 19-inch monitor

Dual-headed IRIS Indigo shares the same specifications as IRIS Indigo, but comes with two 16-inch color monitors.

architectures. Harrell said this extreme integration made packing so much graphics muscle into IRIS Indigo's already compact skin a reality. "The board-level integration issues were incredible," Harrell said, noting the system employs the latest in surface mount packaging techniques.

For Hannah, the true success of Elan Graphics is its graceful mix of speed, functionality and size. Previously, engineers had to sacrifice one or two of the three to optimize the other. "When we set out to do the Personal IRIS, we faced considerable constraints," Hannah recalled. "We wanted to get something out to market as quickly as possible, so we were conservative about what we put into the machine." While the result was the industry's lowest-priced 3D computer, Hannah said the list of unchecked items on his Personal IRIS wish list was lengthy.

Not so with Elan Graphics. Calling the fully developed IRIS Indigo family "the Swiss army knife of computing," Hannah insisted

he has yet to see a more elegant computer system. "The whole product design — the mechanical aspect of how the thing fits together — is very effective." And this time, Hannah said, his engineering wish list is short. "The IRIS Indigo Elan contains about ninety percent of all the things we could have possibly put into this machine."

But the inherent engineering complexity of the graphics technology — and the challenge for Harrell and the others who worked on its design — is the hurdle that, for Hannah, will be remembered as the one to beat. "Chandlee and the other engineers did a fantastic job in defining that whole subsystem," Hannah said. "It's an incredibly complex architecture, but they were able to keep a handle on it."

Harrell agreed. "The biggest success is that we did make it work," he said. "We've got 700,000 gates of custom design in there, along with seven separate gate array and standard cell designs. We basically had the system running with the first spin of the

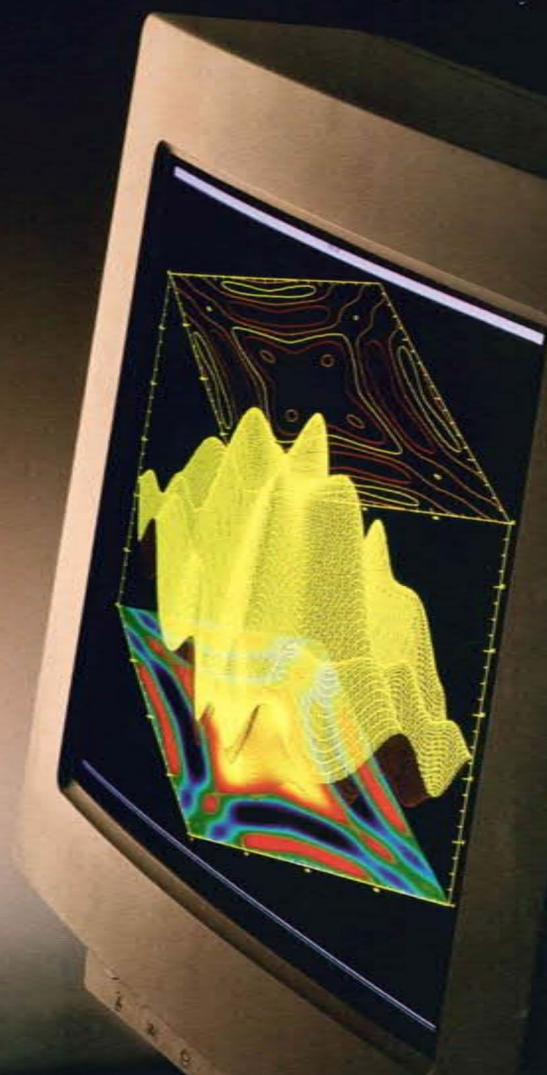
chips. But it only came with the kind of religious zeal that the engineers exhibited while working on this project. They turned it around in an unbelievably short time."

Apparently, Silicon Graphics engineers aren't the only ones to get the Elan religion. Today, Texaco's visualization zealot is an even bigger fan of the IRIS Indigo family. "It's perfect," noted Zeitlin, who recommends computer solutions to Texaco engineers based on their data analysis needs. "There is a mandate from management to move all applications to 3D. The price/performance of the IRIS Indigo family makes it easier for me to seduce my Texaco 'customers' into using 3D."

"This is sizzling graphics," Harrell said. "People look at it and they feel it. With the IRIS Indigo family in place, we really believe we're poised to take over the visual computing desktop."

Carl Furry works with Silicon Graphics' Applications Division.

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Numerics and visualization

In response to the suggestions of its own employees and the growing demands of environmental research and recovery projects, Silicon Graphics has developed an ambitious new informational program designed to encourage Scientific Analysis for Visualization of the Environment. It's called...



By Douglas Cruickshank

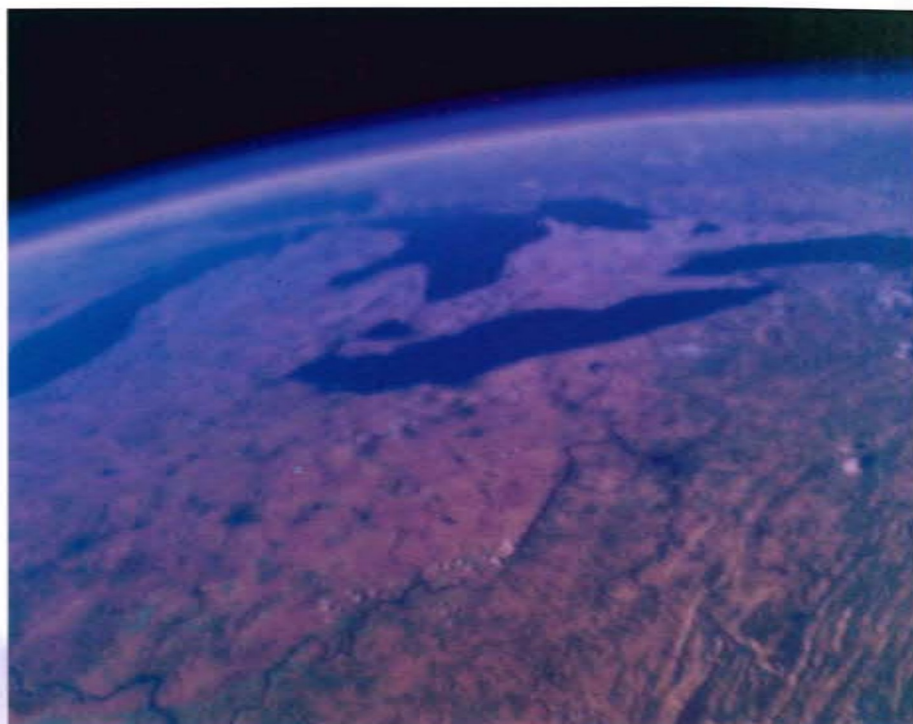
Leslie Doyle is not talking about what she'd planned to talk about. Doyle, Program Manager for Silicon Graphics' new SAVE program, was intending to discuss why Scientific Analysis and Visualization of the Environment is such an important program for the company. Instead, she's talking about the four fascinating characters with whom she spent her Honolulu vacation. "One of them liked to bite," Doyle says. "Another, a little girl, would butt you like a goat. They're just playing, of course, but you have to be care-

ful. They're quite large, you know." Exactly what kind of vacation was this? As it turns out it was the type of retreat one would expect Ms. Doyle to take, because the fun loving foursome she spent it with was made up of dolphins who reside at the Kewalo Basin Marine Mammal Lab in Hawaii. While others may travel to the islands for luaus and body surfing, Doyle spent her visit rising at 6:30 A.M. and, under the auspices of the Earthwatch Volunteer Program, assisting researchers in cognitive science experiments with the highly intelligent mammals. As she talks, one realizes that Doyle isn't off her subject at all. Indeed, the discussion is heading exactly where she intended, for she is passionately concerned with the Earth, the life it supports and seeing to it that real science is applied to the search for environmental solutions — and that is what Silicon Graphics' SAVE program is all about.

"SAVE is a program designed to help environmental researchers use Silicon Graphics' technology in innovative ways to study and visualize environmental issues," Doyle says. "The program is driven by the growing needs in the study of Earth and environmental sciences and also by the growing desire of Silicon Graphics' employees for the company to involve itself in a signifi-

cant way in solving environmental problems. The SAVE program," Doyle continues, "is looking for environmental researchers who need a powerful visualization tool to help them *see* and communicate the outcome of their research. For example, the Centre for Landscape Research at University of Toronto has developed a software application on the IRIS workstation that reads GIS data describing soil types, groundwater, vegetation and land use to aid in planning cities ecologically. The IRIS workstation is an excellent visualization system for such a task because its CPU can assimilate the massive amounts of data required for environmental research, and the graphics engine can create a picture with that data to enlighten environmental professionals and laymen. The SAVE program is designed to assist the environmental researchers reach their goals, combine efforts, communicate effectively, and promote public awareness of their efforts in conjunction with ours."

Doyle's not the only one at Silicon Graphics excited about SAVE. CEO Edward R. McCracken is equally enthusiastic and was pivotal in getting the program started. In a recent conversation he recalled talking with several Silicon Graphics employees who were extremely interested in working on environmental projects. In the course of the discussion he suggested that if a program could be designed that was likely to achieve something "truly significant" he'd see to it that it was supported with money and equipment. "We like to be responsive to the ideas that our employees are passionate about," McCracken comments. "We feel that's the best way to run the company." Now, just a year and a half after that first conversation, Silicon Graphics' SAVE program is fully operational with Doyle in charge and more than thirty "eco-allies" working in cooperation with the program.



From Cuba to the Great Lakes. A thirty second computer animation created from satellite photographs texture mapped onto a globe.

"I believe," McCracken says, "that a company has four constituencies. One is the shareholders, another is the customers, a third is the employees and the fourth is the community and the environment in which we live. As a company, this fourth constituency is extremely important to us. We started the SAVE program because we felt that by making the unique capabilities of Silicon Graphics' technology available to 'change agents' throughout the world — that is people whose work and opinions can really make a difference — we could have an impact on environmental issues. If, by using Silicon Graphics machines, environmental scientists and researchers can understand the world better and, through visualization, apply real science in a way that makes it easily understandable to the public, that will be wonderful." McCracken's long term desire for SAVE is that it help bring a higher degree of scientific consciousness to the environmental movement. Silicon Graphics, he believes, is in an excellent position to achieve this goal because the company's workstations are already used by scientists around the world. Ideally,

SAVE could serve as a dual-direction catalyst — by interesting more scientists in environmental concerns and by encouraging environmentalists to integrate visual computing into their studies.

At present, more than thirty organizations are allied with the program, ranging from the University of Toronto's Centre for Landscape Research (see article on page 15) to the National Center for Super Computing. In addition to large institutions, many smaller organizations working on a variety of compelling environmental projects have been attracted to the SAVE program. In Los Angeles, de Graf and Associates is developing the Electric Atlas (see article on page 38) based in part on data licensed from Global Vision Systems of Bolinas, California, another affiliate of the SAVE program; and Colorado environmental consultants Dames & Moore are using Dynamic Graphics' 3D computer visualization tools and IRIS workstations to assess soil, water and air contamination (both Dames & Moore and Dynamic Graphics are SAVE participants).

In addition to launching the SAVE program, Silicon Graphics has sharpened its focus on environmental concerns by hiring Bill James as GIS (Geographical Information Systems) market manager to complement the continuing contributions of Bill Pickering, who concentrates on managing Earth and environmental sciences for the company. James, experienced in scientific markets and databases, joined Silicon Graphics in July of 1991. "I believe we'll see some very significant new technology emerging from the SAVE sponsored programs," James says. In his view, one of the SAVE program's most important functions may be to educate environmental scientists about the value of 3D visualization as a tool for helping non-scientific people understand scientific ideas. "For

...one of the S.A.V.E. program's most important functions may be to educate environmental scientists about the value of 3D visualization as a tool for helping non-scientific people understand scientific ideas.

example," James explains, "my field (GIS) has traditionally used 2D when representing data, and some of the people in the field have a tough time understanding how to make the best use of 3D visualizations. But with people out there like Brad de Graf, who's doing the Electric Atlas, or John Danahy, who's heading up the Eco-Planning project, the greatly enhanced value of 2D over 3D is being demonstrated. The type of work de Graf, Danahy and others like them are doing shows scientists what is possible and, by simple extrapolation,



those scientists can then see the value of applying this technology to their own work in order to make complicated ideas accessible to a lay audience."

Silicon Graphics veteran Bill Pickering's longtime interest in Earth and environmental sciences, and years of working with the scientific community, has brought him to a similar conclusion. Lately, Pickering has been focusing on image processing as a tool for scientists who will be basing their work on digital data derived from NASA's global monitoring satellites — called the Earth Observing System (EOS) — scheduled to be in place later this decade. "I've always believed that if you can see it, it will make much more sense to you. Scientists who are able to illustrate their work — for the purpose of making that work easily understood by policy makers and funding organizations — are the ones who are going to get the attention, the funding, and will make the difference." Indeed, many feel that those who effectively use visual media

as a communication tool are most likely to get their point across.

One of Silicon Graphics' greatest strengths, Pickering says, is its understanding of the scientific process and its insight into what scientists need to help them get their work done. Regardless of a scientist's specific area of interest, the process he or she follows is quite similar. In describing it, Pickering uses his current interest — EOS — as an example. "The first thing a scientist does," he explains, "is observe. In the case of EOS, NASA will launch satellites that will transmit observational data back to Earth in digital form. Scientists will look at that data — observe it — and then, second, seek to understand it. It's in the second stage — trying to understand the observational data — where they profit enormously from the use of visualization tools. Once they've reached a certain level of understanding they'll move on to the third step — the creation of a predictive model on which they can test their theories; interactively

play with the parameters to establish cause and effect — again, computer visualization is of great value at this point.”

Pickering feels that Silicon Graphics is unique in its ability to offer a comprehensive solution to those working in Earth and environmental sciences. “If you sell hardware without effective software,” he says, “you don’t have a solution for anybody. We’ve made sure that we provide users with the complete solution — UNIX, X Windows, a C compiler, image processing, a visualization front end, a database, word processing — and in the future they’ll come to rely on our multimedia features.”

Scientists who are able to illustrate their work ... are the ones who are going to get the attention, the funding, and will make the difference.

“You see,” Pickering continues, “what’s often missing in discussions of environmental issues is a scientific basis for the concerns that are voiced. Of course the concerns are quite valid, but to make good public policy, you must be able to prove a scientific basis. Visualizations based on irrefutable data cannot be argued with — such visualizations and associated research will make a profound contribution to initiating positive environmental changes around the globe.”

As detailed by Bill James, the principal uses of computer visualization in Earth and environmental science fall into four categories:

- 1) monitoring the Earth’s vital signs — for example, creating visualizations

based on data gathered by the Earth Observing System;

- 2) modeling the changing climate and other significant global fluctuations, such as changes in sea level or vegetation;
- 3) planning, design and tracking of recovery efforts;
- 4) developing presentations to inform, educate and influence policy makers and funding sources.

“As awareness of environmental problems has increased,” James says, “so has regulatory pressure from governments and the demand for three major constituents — potentially responsible parties, regulatory agencies and environmental consultants — to come up with effective solutions. But while solutions can often be very difficult to arrive at, it can be still more difficult to define the problem; the individual making such an effort needs all the help he or she can get.” This may be where the SAVE program proves most beneficial to environmental scientists and researchers. By serving as a hub for such projects, Leslie Doyle hopes that SAVE will prevent duplication of software development and help put people in touch with others who are involved in similar undertakings. “I hope to increase awareness of Silicon Graphics in the environmental research marketplace,” Doyle says, “and create a community of environmental researchers who are conducting their studies on IRIS workstations.”

With the emphasis now placed on environmental issues around the world, Doyle sees the opportunity for a crossover of technology from numerous disciplines not usually thought to be focused on environmental science. “Silicon Graphics is currently involved in many diverse markets (CAD/CAM, AEC, CFD, database, chemistry, biochemistry). Many of the software applications developed for these markets are also very useful when studying the environment. For example, the computational fluid dynamics (CFD) codes that model flow (such as FLUENT from FLUENT, Inc., and ARCPHOENICS from Adaptive Research Corporation) can be used to compute and visualize the transport of pollutants

through soil. This could prove valuable in planning the clean up process — to help in avoiding the escape of toxic pollutants during the cleaning procedure. SAVE has no boundaries,” Doyle adds, “it’s a world wide program.”

Visualizations based on irrefutable data ... will make a profound contribution to initiating positive environmental changes around the globe.

Leslie Doyle hopes that the future development and maturation of Earth and environmental science will bring with it a shift in emphasis from the political to the analytical. “When dealing with emotionally charged environmental issues,” Doyle observes, “humanity will probably never get away from politics entirely. But it’s my feeling that the more we’re able to communicate in terms of verifiable data and research and make that information accessible and understandable to a great number of people, the faster we’ll be able to solve some of the problems we’re having, trying to take care of our planet. That’s why computer visualization is such an important tool for environmental scientists, and that’s why SAVE is such an important program for Silicon Graphics.”

Douglas Cruickshank is a freelance writer based in the San Francisco Bay Area.

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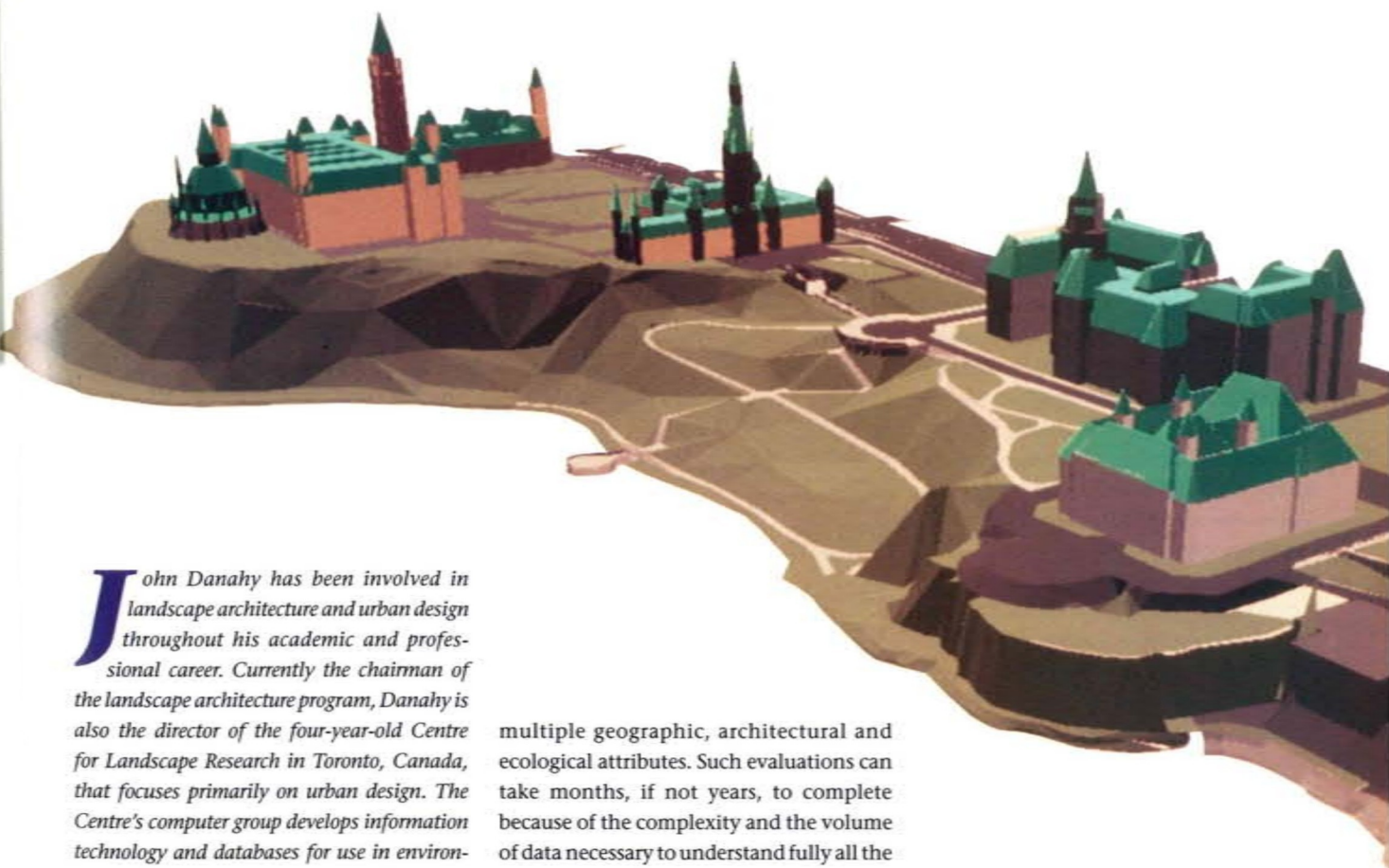
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REVOLUTIONIZING

the way

CITIES

ARE PLANNED



John Danahy has been involved in landscape architecture and urban design throughout his academic and professional career. Currently the chairman of the landscape architecture program, Danahy is also the director of the four-year-old Centre for Landscape Research in Toronto, Canada, that focuses primarily on urban design. The Centre's computer group develops information technology and databases for use in environmental impact assessment and public participation in environmental decision making. By extending the capabilities of current technology, Danahy and his colleagues are revolutionizing the way cities are planned and improving the way development proposals are evaluated.

Assessing the environmental impact of an urban community or an industrial park requires the simultaneous consideration of

multiple geographic, architectural and ecological attributes. Such evaluations can take months, if not years, to complete because of the complexity and the volume of data necessary to understand fully all the implications of erecting structures, building roads, and planting trees.

When the staff at the Centre for Landscape Research first evaluated the public's perception of environmental and ecological issues, they found that many people were overwhelmed by the world's complexity and were unable or unwilling to process much more additional information, let alone determine how to deal with new situ-

By Crispin Littlehales

ations and strategies. There was a definite need for a systematic communication and information medium that could be used to effectively negotiate with people on environmental planning issues without losing

track of scientific or creative information. Computer technology, the staff believed, could serve as an intellectual prosthetic device to help amplify the human capability to make decisions about how the Earth should be treated.

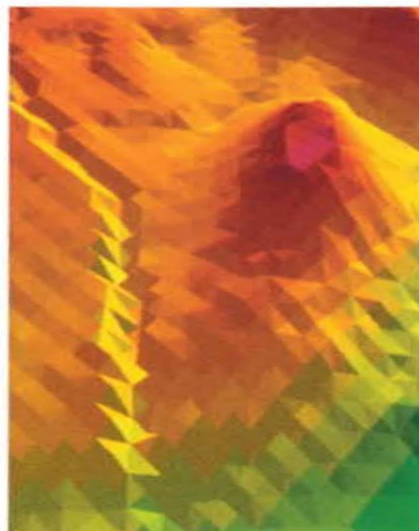
The Centre's computer group accepted the challenge of finding the best way to manifest the ideas of spatial designers such as urban planners, architects and landscape architects. They began working with traditional CAD systems and 3D graphics to use perspectives and generate images. Then, the group used Alan Fournier's early work in general purpose rendering programs and applied those renderings to build models of particular development sites or locations.

A 1984 project examined some of the design scenarios being considered by the National Capital Commission (NCC) in Ottawa for the planning of a ceremonial route. While other professionals offered 2D drawings, the computer group was able, in four months, to put together six 512 x 512 rendered images. These 3D images represented graphically the growth of trees over time, the rolling terrain and the vistas from the proposed road. At this point, the Centre became acquainted with Silicon Graphics workstations and immediately realized the possibilities offered by 4D computer modeling. In addition to their first workstation — a Silicon Graphics 4D/30/20 — the Centre now uses a 4D/310 VGX, a 4D/70GT, a 4D/25TG and two 4D/20TGs, as well as a variety of peripheral devices such as digitizers and a color PostScript™ printer. Since their work involves importing whole data sets from other laboratories, the group also has a Read/Write optical system.

Spatial Literacy

Because environmental design planning is never a lone wolf activity, there is a great need to be able to comprehend a whole development project with all of its various ramifications in a single glance. To make good decisions, particularly during a group meeting, one must be able to blend field data from the ecologist with architectural

and landscape data, as well as information regarding air quality, ground water and so forth. The Centre's computer laboratory is currently developing new tools for visualizing and representing complex data. The software being developed is designed to serve as a professional support tool for use in landscape architecture, urban planning, urban design and geographic planning. The aim here is to provide spatial literacy to users so that they can organize their thoughts and come up with innovative ideas — to enable anyone at a meeting to actually participate in the design process by making suggestions and seeing the implications of those suggestions immediately on the computer screen. In fact, the designer himself will be able to pursue an idea fluidly in an intuitive way during an actual presentation.



Enabling Technology

Because most of the software that is currently available only address pieces of the whole puzzle, the Centre's computer group has developed two different software programs. One, called Polytrim, is its prime research prototyping software. Intended as a guide to software developers, Polytrim is a hybrid of CAD, GIS and image processing, with the elements of these processes fine-tuned to real-time decision making and designer planning. It can perform constraint checks and other operations similar to those done by GIS, but it operates at the micro level of individual decisions instead

of the macro level of broad scale decisions. It is not designed for public use, but rather to point the way to further software development by demonstrating real world applications that actually work.

The Centre's other program is called CLRview (Centre for Landscape Research viewer) and is intended to run as a real-time visualization tool. Designed to exploit fully the capabilities of Silicon Graphics hardware, CLRview makes no compromises to device independence. It is data independent, reading data on a network from any number of different CAD and GIS systems.

CLRview allows anyone with a Silicon Graphics IRIS workstation to sit down, load data from a variety of sources and examine that information. Self-documenting, easy to use and requiring a minimum amount of training, CLRview does not necessitate a complex conceptual or professional model demanding a lot of expertise from the user.

The Centre's CLRview station, whether used as a 2D, 3D or 4D viewing tool, is, in essence, a translator. Its function is to attempt to load the data from as many packages for which the programmers have time to write filters. At the moment, AutoCAD DXF™ is the single most important file standard for which the Centre has built a translator. Other widely used software packages from which files have been filtered include ESRI's ARC/INFO™; raster systems such as MAP GIS™, MAP 2™ and the original MAP Analysis™; Synercom system files or the SIF format and CAD area DXF files such as Architreon™. In addition, Silicon Graphics' Object Format™ and the Centre's own polygon format are available for use. For image processing, the IRIS RGB format and TIF format are usable.

Although this is not complete coverage, the Centre has found that it can get data from most environments through one of the above mentioned formats. Even if someone uses an unfamiliar software package, as long as it conforms to one of the accessible file formats, the computer group



*Image courtesy of University of Toronto,
Center for Landscape Research.*

has been able to read in that information at least at the geometric level.

Because of the Centre's noncommercial perspective, it has developed software (CLRview and Polytrim) and filters that offer distinct benefits not possible from profit-driven products. A comprehensive environmental impact assessment system is simply not affordable to small scale users (like one- to five-person architect offices). Since commercial products must be clearly focused on discrete areas of information to be profitable, serious PC users often need a minimum of five to twelve software packages to accomplish a project. If a single package costs a minimum of \$20,000, and a minimum of five packages is needed for a working office, the cost of the hardware is a trivial expenditure compared to the software investment. So, even if companies eventually bring down the cost of their workstations, software costs may block the way for many potential users.

In contrast, each of the Centre's software tools is much more comprehensive than any commercial product. Recognizing that

environmental design fields are fundamentally interdisciplinary, the Centre used the technologies being developed in each discipline to pool the necessary information into one package.

In developing CLRview, the Centre has realized its goal of putting out an inexpensive piece of software, one or two years before any commercial tool, that allows a user to buy an IRIS Indigo or a Personal IRIS and use it as a visualization platform for data files already made with AutoCAD and other similar software running on personal computers. CLRview complements these software packages by pulling together diverse pieces of data that they produce and making them immediately usable in situations such as meetings and group analyses.

Synergistic Network

An essential part of the Centre's laboratory set-up is a local area network (LAN) connected to the University of Toronto's fiber optic network. It links the computer laboratory with the Computer Science Department where there are four additional Silicon Graphics workstations that can be

utilized. The LAN also links the lab to an internet network enabling the Centre to participate in collaborative research with other universities and vendors such as Silicon Graphics and ESRI.

The Centre has used its Polytrim and CLRview programs in several collaborative projects over the past few years. The SAVE (Scientific Analysis and Visualization of the Environment) project, involving Silicon Graphics, the University of Toronto and eight other universities, deals with ecological city planning. The universities, all using either Silicon Graphics workstations or having very strong reputations in the areas of computer design and use of GIS tools, include ETH in Zurich, University of Strathclyde in Glasgow, the Planning Department at Massachusetts Institute of Technology (MIT), the Landscape Architect Department at Harvard Graduate School of Design (GSD), University of Massachusetts, Universite de Montreal, University of Toronto, Ohio State University and University of Manitoba. The SAVE project is studying the role real-time 3D computer graphics can play in the way people look at making environmental decisions, how people can better examine the information they need and how designers can interact more readily with their models to change them in pursuit of a line of thinking.

The most advanced group in the SAVE project is the Zurich group that has a Silicon Graphics VGX and several other IRISes on which they run ARC/INFO from ESRI. Since the software is compatible from the high-end to the low-end computers, work done on any computer can be shared on the network. Zurich has taken the Centre's software and adapted it for a simulation of the impact of siting a hydroelectric dam in the Alps.

The Harvard group is the most active in using the tool in a prototype-structured environment involving environmental decision making. They have sponsored three workshops including one with University of Hannover in Germany at the Hannover 2000 Expo. For another project, Harvard's Environmental Planning Studio used a microcomputer-based raster GIS system and then downloaded their whole term's work onto four Silicon Graphics 4D/35TG workstations. This information will be used as the Harvard group works on a collaborative project with University of Utah to assess the impact of the development around the Winter Olympics site being proposed near Salt Lake City.

The CAP Cities Project involves the Centre and Massachusetts Institute of Technology. The Centre has been working on urban design for the NCC in Ottawa, involving a lot of detailed design, visual impact assessment, urban design density transfer work and a bit of GIS work on greenbelt planning. MIT has been helping the National Capitol Planning Commission (NCPCC) in the United States with their regional planning issues. In the CAP Cities Project, MIT and the Centre are combining their advisory skills to assist both organizations in using computers more effectively to do their work.

Specifically, the Centre helped Massachusetts Institute of Technology pull together a 3D model of Washington, D.C. Taking a data set generated on a CAD system by the consulting firm Skidmore, Owens and Merrill, the Centre and MIT worked together to combine this database with GIS information from the NCPCC's files, and to make a visual impact assessment of new building proposals, similar to the ones the Centre produced for Ottawa. In return, MIT will offer its expertise in using ARC/INFO and similar programs to help the Centre do larger scale examinations of transportation planning and census data for the Ottawa planning commission, both citywide and regional. A proposal is being submitted for the Centre to present a special Capital Cities workshop at the 1992 Urisa conference.

Exploring New Options

Working with other vendors is another key area of activity for the Centre. With assistance from Silicon Graphics, the computer group has been conducting a series of exercises with ESRI to determine how useful Polytrim and CLRview are when run in conjunction with ARC/INFO. The first project focused on bringing together utilities, underground utilities and terrain models of the Ohio State University campus, and putting them into ARC/INFO.



The second project involved pulling together the Alpha version of ARC/INFO's 6.0. This version allows the user to superimpose a land use model or 2D map over a TIN model. A very powerful tool, it illustrates for people a specific aspect of a landscape by breaking the surface of the earth into a series of triangles that approximate that particular surface. Using an IRIS workstation, those triangles can then be rendered as polygons, providing a solid surface model of the earth with any kind of environmental schematic information draped over it. With these models in place, designers can add details like transmission lines, buildings and forest covers. The latest work on this project has been to take polygon areas defined as, for example, a particular forest site, and use the VGX to place texture map representations of each tree into that landscape in real-time.

The third Centre/ESRI project uses the relational database in ARC/INFO, com-

bined with a traditional city assessment map and a building footprint map, to read in automatically a complete 3D model of a neighborhood from what was formerly just tabular and 2D information. With this filter, a city planner using ARC/INFO can simply window an area he wants to look at and walk around in, and automatically have the database there. Traditionally, this exercise took at least two weeks to digitize. Each separate project required the same start-up time and investment. When CLRview becomes available, cities that have made the initial investment in ARC/INFO should be able to access data and look at a specific area as a byproduct of their normal mapping and database exercises, with no additional expenditures in software.

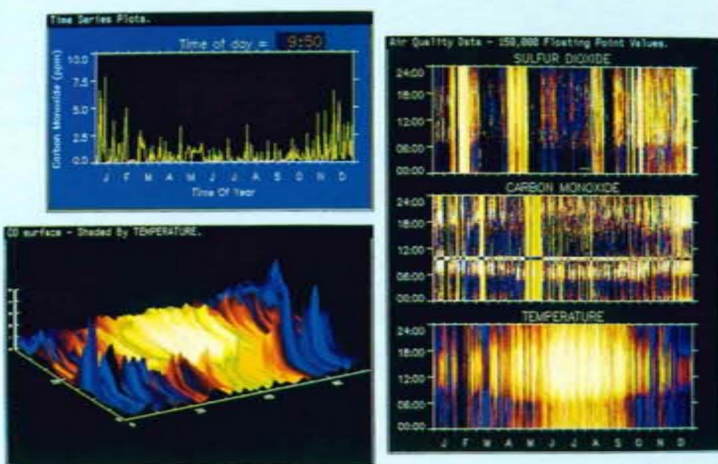
A municipal planning office running ARC/INFO on an IRIS Indigo stands to save tens of thousands of dollars by organizing its database according to a formula defined by the Centre and by using CLRview. The computer group recently experimented with ESRI's Maplewood™ demo. In one day, the group used ARC/INFO and CLRview to produce 3D models of that urban site automatically from the Maplewood database. The group also produced a 3D prototype of a rural site as part of an ARC/INFO consulting project for a recreational community development in Japan called Kawauchi Heights. A 3D visualization of similar databases could easily have absorbed \$70,000 of a \$100,000 budget.

The CLRview software may well be the single most significant breakthrough that has been made in terms of enabling technology in this area. Urban and landscape design professionals now have access to affordable technology that will help them make better development decisions that take into account the increasingly delicate ecological balance of our planet.

For more information about CLRview, please contact: The Program in Landscape Architecture, University of Toronto, Tel: (416) 978-6788. E-mail: land@dgputoronto.ca.

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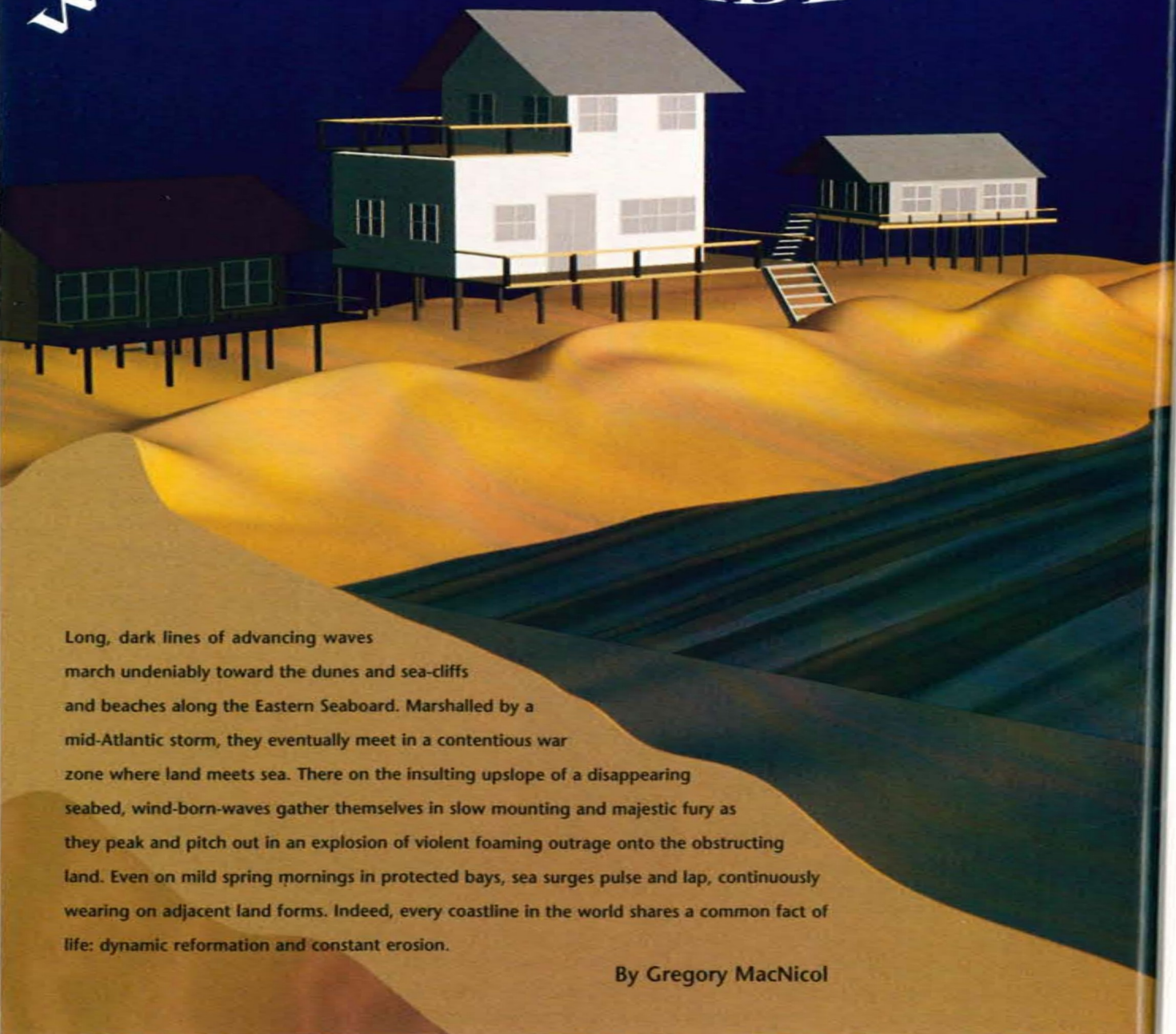
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Long, dark lines of advancing waves march undeniably toward the dunes and sea-cliffs and beaches along the Eastern Seaboard. Marshalled by a mid-Atlantic storm, they eventually meet in a contentious war zone where land meets sea. There on the insulting upslope of a disappearing seabed, wind-born-waves gather themselves in slow mounting and majestic fury as they peak and pitch out in an explosion of violent foaming outrage onto the obstructing land. Even on mild spring mornings in protected bays, sea surges pulse and lap, continuously wearing on adjacent land forms. Indeed, every coastline in the world shares a common fact of life: dynamic reformation and constant erosion.

By Gregory MacNicol

It is a ceaseless global struggle. Those who abide near the margins of our land-bound oceans soon realize that beautiful sandy beaches are remarkably unstable and do not necessarily afford protection from the incursions of storm driven seas. And depending on where you live, the receding coastlines may be viewed as a problem. In Japan, for example, where hunger for land outstrips demand, massive

structures are erected to protect valuable real estate and forestall the ongoing assault of restless and imposing seas.

Likewise, tiny Holland has long battled — and many times lost to — the relentless power of the North Sea. The Dutch spend an enormous number of their tax guilders building sea walls — their equivalent of our defense industry. In other parts of the

world, where resources are insufficient to support the construction of sea-holding structures, buildings are lost daily to the onslaught of surge, storm and tide.

Indeed, viewed long range, our endless attempts to “preserve” shoreline features seems like a Sysiphean task. Mankind is eternally attempting to shore up land, wresting it from a watery nemesis.

Beach Formation and Reformation

So how does it all work? How can we best understand the interplay of land form and sea current that forms and reforms our coastlines? These primary questions are exactly the kinds of questions that are being addressed — and literally visualized — by computer savvy researchers at Duke University.

According to Professor Orrin Pilkey of Duke University, nature should not be viewed as the enemy. In fact, Pilkey asserts that before man arrived there was no conflict. The process of evolving barrier islands, beach development and shoreline migration is one of constant adjustment of grand natural phenomena synergistically integrated with global changes such as ocean levels, temperature shifts and tectonic movements.

Prof. Pilkey's interest in shoreline retreat was whetted when his parents' Mississippi home was destroyed by the onslaught of hurricane Camille in 1969. For decades his personal interest in coastal geology deepened and took the public form of the "Living With The Shore" series, books which he co-authored and developed his interest in coastal geology. Indeed, coastal issues have become his lifework, taking him to a position of remarkable esteem as Director of the Program for the Study of Developed Shorelines at Duke. Pilkey's research, which is considered radical, indicates that attempts to harness the sea and "control" shoreline features is of questionable utility and ultimately of little benefit to any but special interest groups.

And at considerable cost. Pilkey's bottom line argument is that we continue to mismanage our beaches because our engineers rely on models — essential in engineering — that are erroneous. Pilkey concludes that the reason engineering success is unpredictable is because traditional models are static and based on closed systems. Furthermore, there is still scant agreement or even communication between the engineers who build massive and expensive shoreline structures and the scientists who study shoreline migration — and the aftermath of ill-conceived coastal construction projects.

What Pilkey and his group are discovering is that understanding the region between deep ocean and shoreline is critical to an analysis of underbeach migration and development. This is where sophisticated computer use comes in. One of Pilkey's Developmental Shoreline group is Rob Theiler who has been studying what's called the "shoreface sedimentary process".

Theiler concurred with the group consensus that existing models were inadequate and misleading and so set about to gather the requisite data to develop new ones. Theiler's sources and tools are diverse to say the least. His emerging shoreline models include data from a number of esoteric theoretical disciplines including particle theory, dynamical systems, chaos, catastrophe dynamics and simultaneous interactive systems theory. He also gets data from three meter long core samples of the ocean, side scan sonar, seismic instrumentation and from fishermen who provide details regarding outcroppings and changes in the fishing grounds.

It turns out that shoreline interactions are so complex, and interpreting the intricate findings so complicated, that Theiler is now taking all of the available empirical instrumentation-based data and finding ways to visualize it. That is where Silicon Graphics comes into the picture. Silicon Graphics has become an important ally in the group's effort. Using a new Silicon Graphics workstation, Theiler plans to incorporate different kinds of data, (e.g. seismic, sonar, etc.) and transpose them on their respective and adjusted axes so that the interplay of the data can be visualized dynamically.

Digital Surfing

The key to the conceptual understanding of processes like these is visualization, according to Theiler. "Creating thirty images of the beach to the abysmal plain [where most of the world's sand is located], gives us a better understanding about how the various complex forces work together." As Theiler observes, "We cannot predict shoreline migration based on systems that we don't understand." When asked how long it will take to have adequate models of

shoreline behavior, Theiler replied, "With increased effort in instrumentation and these new visualization tools, it may take about three decades." Clearly, these scientists are into long-haul solutions.

Using IRIS-based 3D visualization software, Theiler is applying a three pronged approach: draping seismic data underneath regional stratigraphy to look for outcrops; locating old inlets; and, paleochannel searches (finding the locations of old rivers).

Silicon Graphics is actively interested in projects such as his. The charter for Silicon Graphics' S.A.V.E. program (Scientific Analysis and Visualization of the Environment) is "to educate environmental researchers in the use of IRIS workstations in order to understand our changing planet." S.A.V.E. projects include ecological city planning, animation of the earth from space and various applications of the principles of Reduce, Reuse, Recycle. S.A.V.E. has thus become an important ally in Duke University's ongoing effort to understand our coastline geology.

What Theiler is learning has surprised everyone: beach and barrier island development is far more complex than anyone realizes. For example, core samples taken on the seaside of barrier islands off the North Carolina coast show black stained lagoonal sediments that do not occur on shorefaces. The land-based sediments are apparently migrating under the island.

Furthermore he has learned that the shoreface can act not only as a barrier but as a kind of filter and conduit for exchange of materials moving from the ocean to the land. Theiler and his fellow researchers have discovered that details such as sand particle size, vegetation, human interaction and storms all play influential roles in shoreline development.

Where's the Beach, Dude?

A major goal of Pilkey's group is to evaluate the effectiveness of man-made shoreline interventions such as beach replenishment and sea wall construction. Pilkey and his group have observed that there are three

basic options for the management for shoreline erosion problems, or termed more correctly, shoreline retreat. The beach area can be stabilized and structures protected via "hard" methods, such as large stone or cement sea walls. The second option is to direct our efforts toward "soft stabilization" of the beach via such methods as sand replenishment. The third, seemingly obvious, solution is to adjust or adapt to the "retreat" by relocation of threatened structures, such as habitations and other public facilities.

According to Pilkey's preliminary findings, the first two "solutions" often invite disaster. Pilkey has shown that sea walls actually precipitate accelerated beach degeneration. Given a smaller area to work, wave action transports more sand seaward than would be the case if the seawall had not been built. And sand replenishment is a temporary expediency at best. In fact, of the ninety beaches that have been replenished with new sand along the U.S. Eastern Seaboard, only one remains. The exception is a \$60 million Miami beach which is still intact after ten years.

The folly of beach replenishment is apparent on beachfront properties throughout the U.S. On the East Coast for example, several projects attempting to restore and "replenish" migrating sand for an estimated forty years lasted only five years before the project was abandoned as hopeless.

The last option, relocation, is not surprisingly an unpopular alternative. Yet, there is much to recommend it, from a long range perspective. It preserves the beach, saves massive shoreline stabilization, and saves buildings that otherwise would be lost.

Pilkey takes pokes at obvious attempts to "repair" beaches, particularly for wealthy, influential, beachfront homeowners. Pilkey adds that the massive amount of money U.S. taxpayers are spending to contend with coastline maintenance is literally money down the drain. Furthermore, the projects unintentionally destroy valuable coastal habitat throughout large regions.

Pilkey points out that numerous government financed attempts to engineer beach "stabilization" have failed in the past and that most projects are doomed to failure before they are started until we carefully reassess previous efforts. He points out that the Army Corp of Engineers consistently fails to follow up on past projects. Instead, he would like to see cooperation between the scientists and the engineers.

But a more fundamental goal is to provide a better understanding of how beaches work, and how land and sea interrelate dynamically to shape our changing shorelines.

With this information, we will be able to make better decisions about shoreline use. Instead of destroying pristine beaches such as what happened recently along the New Jersey shoreline (a beach now useless and littered with broken cement and metal from failed sea walls), we can plan to work with nature. The professors at Duke University are suggesting — via their research — that to work against her is presumptuous, hubristic and, ultimately, futile.

Gregory MacNicol is a freelance writer based in Santa Cruz.

Duke University

To convey the principles of shoreline erosion and beach replenishment without immersing lay people in highly saturated scientific models and terms, Professor Pilkey chose another route: computer animation. Pilkey's goal was to produce a thirty minute public broadcast video explaining — and illustrating — what his group of researchers has discovered. Luckily, in nearby Durham, North Carolina, the Flying Foto Factory offers advanced computer animation services for the broadcast video and theatrical film industries.

The Flying Foto Factory is a small computer animation shop with, at that time, one Personal IRIS workstation and a limited range of video support hardware. Although Casey Hervert, the owner and animator, was experienced in video design and production, this was to be his first big 3D digital animation assignment — a large one considering that the program included almost nine minutes (15,300 frames) of computer generated imagery. Rendering time alone, for example, consumed almost all of the three months allotted for the project. Hervert used Explore™ animation software from Thompson Digital Images (TDI), which was an excellent selection because it was well-suited to the creation of complex models and motion scripting. Despite the power of the Personal IRIS workstation, Hervert found that creating believable waves over beaches was a particularly difficult challenge, and indicating believable beach movement also proved to be a formidable technical and artistic assignment.

Another problem Hervert encountered is commonplace in the computer animation business. "I find that even the most informed clients sometimes lack a clear idea of how to translate a concept into video, so the timing of the sequences can get way off. On this project, what was supposed to be ten seconds of detailed wave motion turned into thirty seconds of animation — these little discrepancies can really add up you know."

Yet, despite these difficulties, Hervert's animation proved smooth sailing — in playback mode. In fact, Hervert discovered that after creating the 3D models and setting up the motion, the Personal IRIS ran flawlessly for the whole project. Because of this performance, the Flying Foto Factory was so impressed with the IRIS workstation that Hervert acquired a second Personal IRIS and is planning to purchase an IRIS Indigo in the near future. A feature that Hervert particularly appreciates in justifying adding new workstations is the IRIS workstations' ability to integrate with one another. "The two PIs work together on a single project while still allowing full UNIX multitasking," Hervert enthused.

While the Pilkey/Hervert video production was not a scientific representation, it served its intended purpose: to convey clearly the amazing complexity of wave motion from different points of view. Now, armed with this vision, engineers, oceanographers and interested lay people can incorporate Pilkey's conceptual model into their plans and decision making.

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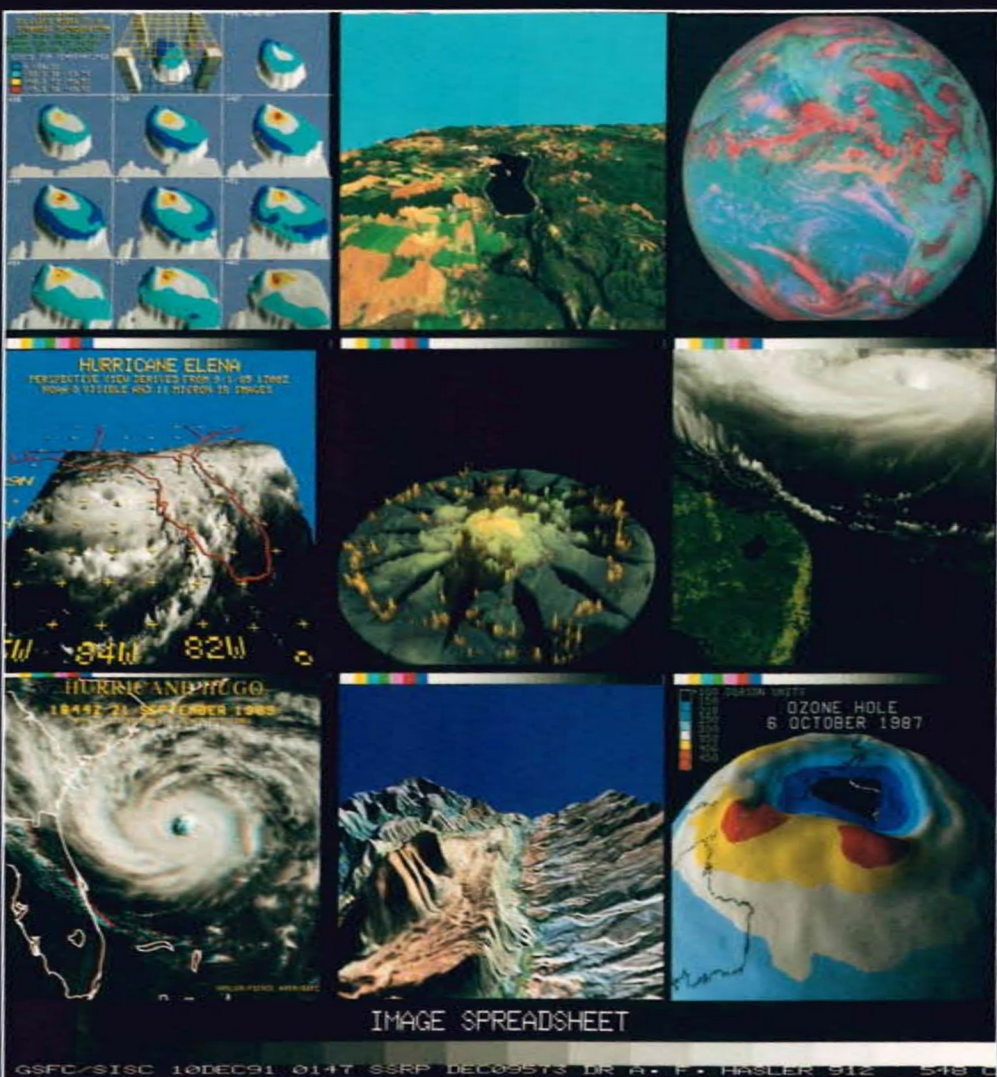
When Fritz Hasler started work on his Ph.D. at University of Wisconsin in 1965, the university was using photographic images and television instant replay equipment to interpret satellite data. Said Hasler's professor: "This ought to be digital."

In 1974 Hasler went to the NASA/Goddard Space Flight Center where he started satellite image interpretation using what was, at the time, a very expensive digital RAM. The images were less than satisfactory. "We had 512K by eight bits black-and-white and 24-bit color," says Hasler. "It was like working with a postage stamp or a fiche. Now we can fill a 1280 x 1024 screen and browse through a much larger image."

Hasler is happier now, but far from satisfied. The trouble is that as technology has grown, so has the flow of data from space. GOES (the Geostationary Operational Environmental Satellite) has sent down a 208 Mb, eight-bit-per-pixel image of the earth from the distance of 40,000 kilometers every thirty minutes since 1974. Then there's LANDSAT, NOAA and other orbiting and airborne sources, with more on the way. And the trend is to use more instruments with more channels. "We're getting mountains of data," says Hasler.

This raises an obvious question. How can anybody possibly sift through those thousand or so multi-megabyte images and make sense of them to benefit us and our planet? In the best of all possible worlds, researchers would be able to make side-by-side comparisons, move freely through the images by time, locale, channel and presentation, zoom or reduce, and animate a time series.

That world is not yet here, but vision, hard work and a Silicon Graphics IRIS 4D/340 VGX workstation have



Printout of an ISS containing a wide variety of data, including comparisons between Hurricane Elena (1985) and Hurricane Hugo (1989). The images in the cell at upper left are based on a model of the development of a tornadic thunderstorm. The cell is nested in the spreadsheet, and can be called up separately.

THE EARTH on a SPREADSHEET

By Grant Ellis

brought it closer than ever. Fritz Hasler, K. Palaniappan and Michael Manyin at the NASA/Goddard Laboratory for Atmospheres have written loop, rgb_zoom, im_stereo, mosaic and other prototype modules. Their colleagues Eric Weinstein and Dave Pape have written flyby. Together they have created a high performance interactive image processing program.

Creating An Interactive Image Spreadsheet

Fritz Hasler likes spreadsheets. He keeps one on his desktop that shows the X and Y dimensions of the images being displayed, number of bits per channel, data transfer rates, looping speeds and animation rates on his IRIS 4D/340 and IRIS Indigo. Jim Dodge, a NASA Research Program Director, asked him "What about an image spreadsheet?" This question led, eventually, to the Interactive Image Spreadsheet (IIS), based on the traditional numerical spreadsheet paradigm.

Each IIS cell contains a complete original or derived image, a partial original or derived subimage, a projection of a multidimensional data set such as a 3D surface, and a glyph or graphic symbol representing an image. A typical IIS matrix could consist of an array of 160 x 128 pixel images, all of the same geographic area. The columns might represent channels of data, and the rows might represent time increments. For a different look at changes over time, the time-series images can be animated in a single cell. Displayed or printed out, the cells tell a visual story that permits easy comparisons. The IIS allows researchers to compare, for example, Mount Pinatubo with the Kuwaiti oil fires, the state of the ozone layer with surface temperatures, or the El Niño current with North American rainfall. If the selected images do not tell a useful story, the IIS provides the ability to add, delete or replace cells, rows or columns.

"Say you had calculated the vegetation index from LANDSAT data," says Hasler, "and you didn't like the results of the equation. You just substitute another index, zoom up the resulting frame, and compare the two. You can expand the vertical dimension, change colors, whatever; you get the idea." Standard mathematical functions can be performed easily on individual cells or multiple cells.

IIS is not limited to 2D as are traditional spreadsheets. A literal or virtual third dimension can be added in the form of pages or layers. If the rows of the top layer are the months of 1991, the rows of the second layer could be the months of 1990. Says Hasler, "We find the 3D concept invaluable in looking at these large data sets. Even if it's not intuitively a third dimension, we present it that way because our eyes and minds are so adept at working with those kinds of data."

The IIS is also useful as an image development tool. Hasler uses it on his IRIS 4D/340 VGX workstation to trace raw data up through correction, enhancement and product derivation, displaying the developing image at all its stages. They can back up and try a different algorithm, or detect the introduction of artifacts.



NASA's Laboratory for Atmospheres used roam and zoom to look at the climatological effects of the huge smoke plumes from oil well fires in Kuwait. This is a subimage of a LANDSAT TM scene using channels 7, 4 and 2 in false color, taken in May, 1991. The environmental effects are trivial compared to the eruption of the Philippines' Mount Pinatubo the following month.

This is not the first image spreadsheet concept to be developed. It is, however, the only one to offer a 3D spreadsheet paradigm with high-performance image manipulation. The team is creating a GUI that will operate in X-Windows™.

Chernobyl: A Test For The IIS

Hasler calls the IIS "more a concept than a reality". As a concept, it is doing very well in the real world. One IIS objective was the ability to animate long regular time series images to demonstrate change. A three-column IIS, for example, can be displayed on the screen as three animated cells or as a single animated cell switching between the three columns. Animation is particularly useful for studying the effects of natural and man-made disasters.

The team recently studied the effects of the April 1986 explosion and fire at the Chernobyl nuclear reactor in the Ukraine. Hasler and his associates prepared an IIS using LANDSAT images of Chernobyl taken the year before, three days after and several months after the accident. Using an IRIS 4D/340 VGX, they zoomed and roamed through a three-channel 2048 x 2048 image. That translates to 4.2 Mb per channel, or 12.6 Mb per image.

"We were just browsing," says Hasler. "We were looking at channel 7; we could see the heat of the reactor fire. All of a sudden there was a big brown smudge in the images. We looped quickly through the time series. They were dumping wet sand from helicopters. The roads suddenly went from ten yards wide to one-hundred yards wide; they were plowing along them to turn under the radioactive dust."

The Chernobyl IISS exemplifies the concept Hasler has been working toward — his idea of the kind of dataset that observers and researchers would want to look at. Still, he is not satisfied. "The problem with it is, it's static. It's low resolution. And you can't change anything, right? So if we ever get this thing implemented the way I'd like to see it, you'd be able to roam that whole spreadsheet. All the channels. All those little cells.

"For example, there's a cooling lake at Chernobyl. We were looking at it in channel 6 eleven-micron infrared. We wanted to put that lake in the middle of the frame, and we couldn't. We had to compromise." With Hasler's visionary browser, he would simply select a spreadsheet cell and roam and zoom to center the lake in the frame. Browse tools like this are the main emphasis of Hasler's work today.

Building A Spreadsheet Superbrowser

As part of the IISS demonstration product, the development team is creating a suite of browse tools — what Hasler calls the superbrowser Front End — to help NASA cope with its immense streams of image data. With their spatial browser, developed in house, they can zoom across a 182.4 Mb GOES image, with its one-kilometer resolution, to pick out such relatively small features as the beaches on Pacific atolls. "We're not the first people to think of this idea," says Hasler. "But I'm not aware of anybody who has a two-dimensional roam in X and Y directions over such huge areas in a high performance mode. We use our IRIS 4D/340 to do flyby and RGB zoom.

"Using Silicon Graphics' shaded zoom product, we can zoom up to an eight times enlargement before it stops making sense as an image. If you limit the image to 2K by 2K, you can reduce forever or zoom forever. But, reduce breaks down after a few iterations."

Their temporal browser, also developed in house, is set up to look at long animations. It allows NASA to load a long time sequence and instantaneously jump to any frame in the time sequence, or zoom

through it quickly and stop on a specific frame. The team wants to make the temporal browser more useful by developing more tools, such as the ability to animate every tenth image, or jump to a specific time.

"You have to have a spectral browser," says Hasler. "Silicon Graphics has written the best one we've seen so far. It's part of a demo that includes the prototype for HIRIS, which will be aboard the EOS satellite. Instead of seven channels, HIRIS will have one-hundred-ninety-two, and AVIRIS, its aircraft prototype, has two-hundred-twenty-four. When we start getting data from the prototype, we'll have to be able to browse through all two-hundred-twenty-four channels and decide which one-hundred-ninety-two are the most useful. It's bad enough choosing among seven channels. Can you imagine one-hundred-ninety-two?"

There are worlds of data to be analyzed and the planet needs all the help it can get.

The other browse tool that Hasler's group wants is a dynamic range browser. It is needed because most of us can only discern thirty-two brightness levels — the equivalent of five bits — with the naked eye. Hasler can conveniently display two-hundred-fifty-six levels (eight bits), in black and white. That's fine for the 6-bit GOES image, which contains sixty-four levels. Silicon Graphics' current workstations handle twelve bits, or four-thousand brightness levels, permitting interactive browsing through the dynamic range for detail that cannot be seen in compressed data. With a hardware lookup table, users can interactively expand, slice and zoom dynamic ranges.

Hasler's vision extends even further. "We're thinking of schemes that will allow us to expand the dynamic range beyond

twelve or thirteen bits and let us establish a higher standard — say 16-bit data, which would give us sixty-four-thousand gray levels."

After the dynamic range browser, the team intends to develop a high volume data browser to deal with applications where there may be large volumes of data on line. Hasler projects completion of the IISS and the browsing tools by the fall of 1993. The IISS and the browse tools eventually will be available through NASA's COSMIC outlet.

The Bottom Line: Throughput

Hasler's job is to push the image processing envelope. The Goddard team's IISS demonstration system is built around an IRIS 4D/340 VGX workstation, and it is built for speed: four MIPS 3000 PROCESSORS, 36 MFLOPS and 256 Mb of RAM. The workstation is Ethernet-linked to a 64 Mb IRIS 4D/310 server with 10 Gb of hard disk capacity and a 5 Gb 8mm tape storage device. Through the 125 Mb/second Goddard UltraNet™, the workstation is linked to other databases and supercomputers. The team works at a 1280 x 1024 color monitor with double buffered 32-bit color, an 8-bit stencil, a 24-bit z-buffer, 32-bit texture, 4-bit overlay, and 8-bit window pane layers for a total of one-hundred-forty bitplanes.

How fast is fast? NASA needs smooth, fast zoom and roam operations to evaluate data. Silicon Graphics' IRIS 4D/340 VGX workstation has demonstrated these operations on images as large as 5965 x 6967 pixels x 24-bits (125 Mb), as it did in the case of the Kuwaiti oil fires. The team can animate 512 x 512 x 8-bit images at seventy frames per second and 512 x 512 x 24-bit color frames at thirty-seven frames per second with full interactive control. The team has run nine-hundred-frame animations requiring 236 Mb, and has loaded full sized multispectral LANDSAT TM scenes for visualization.

Still, Hasler is far from content. He wants more and better tools to process images. There are worlds of data to be analyzed and the planet needs all the help it can get.



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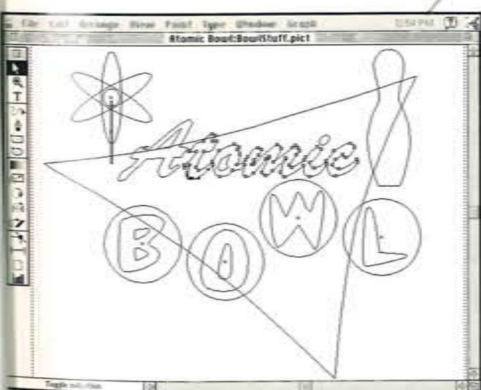
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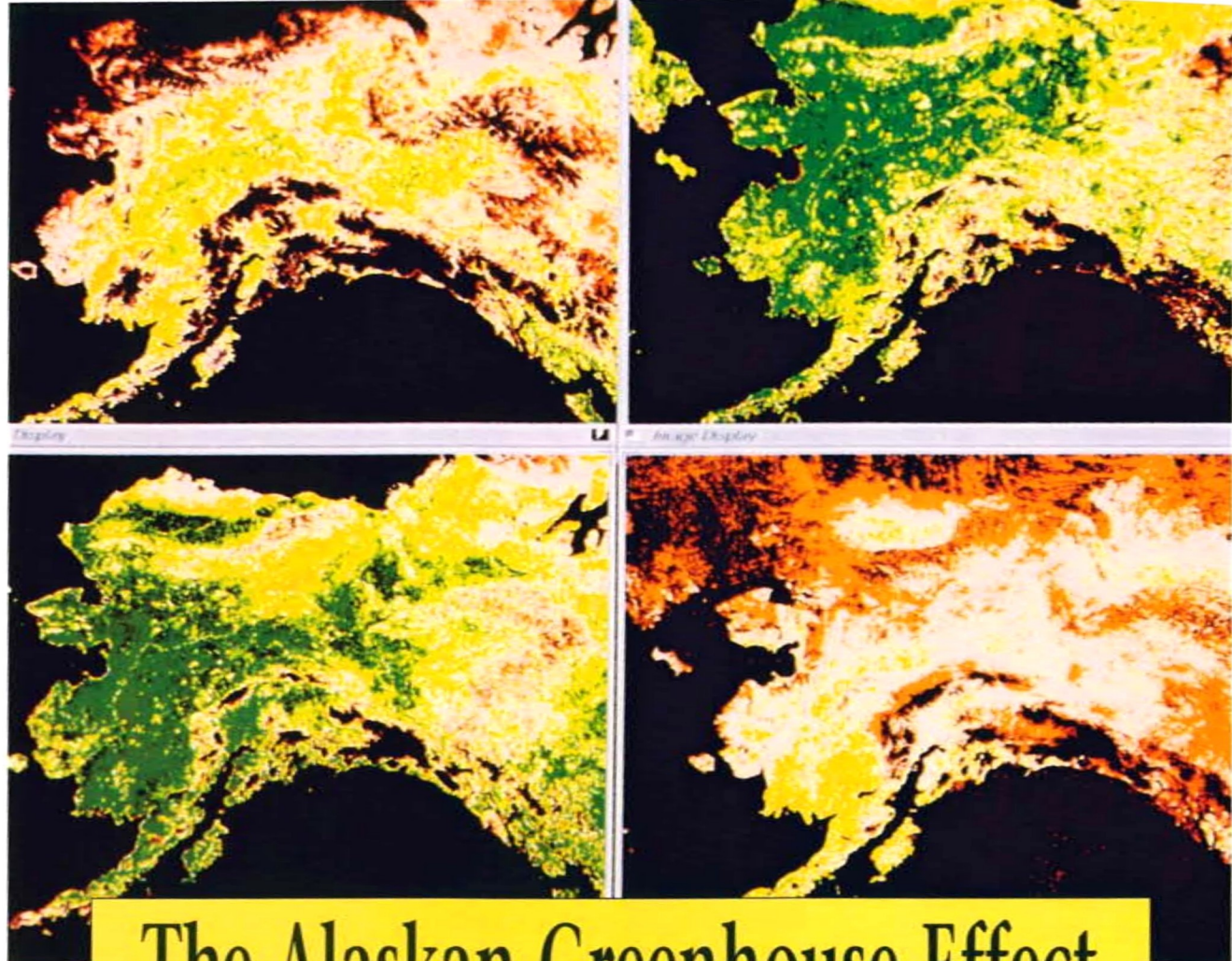
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The Alaskan Greenhouse Effect

Scattered among three buildings at NASA Ames Research Center is a group of scientists with a mission focused, not on man's exploration of the universe, but on our own planet Earth. Based near Mountain View, California, the Earth System Science Division at NASA supports a diversity of research. The research ranges from studies of the depletion of stratospheric ozone, to satellite and aircraft-based observations of the Earth's surface, to studies of the physical, chemical and life processes that change our environment.

One area of research in which NASA has taken an aggressive lead is climatic change. As we conclude the warmest decade in recorded history, there is growing evidence that mankind may be inducing climatic change on a global scale — altering the atmosphere through activities such as manufacturing and fossil fuel combustion.

Methane is one of the most active of the "greenhouse" gases. It participates in the lower (tropospheric) and upper (stratospheric) chemistries and significantly contributes to the Earth's energy balance. The atmospheric concentration of methane has increased over the past century in direct proportion to the human population and is continuing to increase at a rate of one percent per year. The sources of methane are many and include mining and combustion of fossil fuels as well as natural emissions. The primary natural source is anaerobic bacterial decomposition of waterlogged, organic-rich soils that occur in swamps and other wetlands. The northern high latitude tundra (treeless wetlands) and taiga (for-

ested) ecosystems, such as those found in Alaska, are of particular interest. They represent nearly half of the Earth's wetlands. All current climatic models project a significant annual warming of 4–8°C in the northern high latitudes. This could lead to warmer winter and summer soil temperatures and longer growing seasons for these ecosystems. Vast quantities of carbon are stored in these ecosystems as peat or frozen soils. Should greater climatic warming occur, the carbon stores would become available for bacterial decomposition, releasing additional greenhouse gases and leading to even greater regional or global climatic warming.

By Gayle L. Graves

The Ecosystem's Science and Technology Branch, the Planetary Biology Branch and the Atmospheric Chemistry and Dynamics Branch at Ames are collaborating to assess the role and interaction of methane emissions in scenarios of climatic change for northern ecosystems. This research is supported by NASA's Terrestrial Ecosystems, Interdisciplinary Research in Earth System Science, and Advanced Technology Development programs. Since 1987, the High-Latitude Carbon Emissions project at Ames has focused on the subarctic forested wetlands and the Arctic tundra of northern Alaska. The project is led by researchers Dr. Leslie Morrissey and Dr. Gerald Livingston of TGS Technology, Inc.

Their approach integrates seasonal remote sensing observations of the Earth's surface features with *in situ* (ground-based) measurements and process models of methane emissions and controlling factors. These disparate data are combined in a quantitative regional mapping of methane emissions. Subsequent climatic changes are based upon observed interannual variability. Relations to controlling environmental factors can be simulated in computer algorithms to project the responses of these ecosystems to climatic change.

The heart of this effort is the remote sensing of the Earth's surface. Ames Research Center has been involved in airborne and satellite remote sensing since the early 1970s. The aircraft scanning systems have been carried aloft by various types of aircraft including the C-130, ER-2 and the DC-8. These systems gather digital imagery using infra-red photography. James Brass of the Ecosystems Science and Technology Branch offers, "Ames' development of ecosystem research was an appropriate match of instrumentation and expertise."

Several satellite-based sensors are also employed. They include the Landsat MSS (Multi-Spectral Scanner) and the TM (Thematic Mapper), the French SPOT and the AVHRR (Advanced Very High Resolution Radiometer) on the NOAA (National Oceanic and Atmospheric Association) meteorological satellites. Each sensor is capable

of acquiring four to seven channels of information in discrete areas of the visible, near-to-mid-IR and thermal regions of the electromagnetic spectrum. Spatial resolutions range from 20 m² (SPOT) to 1 km² (AVHRR). Areas imaged range from 100 n.mi.² to millions of km².

Vast amounts of satellite data are collected daily. Modeling computations demands rapid numerical processing as well as efficient user interaction for the display and interpretation of results. Researchers wished to assess the effects of potential changes in rates of methane emissions using variables such as precipitation, solar radiation, vegetation, microbial decomposition rates and temperature in their study. A structural framework for the development of advanced computer models was proposed. It would facilitate the evolution of advanced models through the integration and animation of derivative data sets. Data would be drawn from satellite imagery, actual ground-based measurements and simulation parameters. At this point, a Silicon Graphics Personal IRIS 4D/35 and file server came onto the scene.

A prototype, called the Modeling Visualization System (MVS), was constructed by William Acevedo. Acevedo is a physical scientist whose work at NASA Ames is partially funded by the United States Geological Survey (USGS). Using the IRIS Graphics Library, Acevedo built an interactive, icon driven environment. The MVS features methane modeling and simulation tools capable of simulating a specifiable period of study. Previously stored data is pulled from disk to make calculations and simulations. Currently, selected variables are preprogrammed for the researcher. Image changes are visualized on a per-pixel basis. Soon, as the prototype develops, the researchers will be able to set variables interactively. In the modular environment, process levels and simulation models can evolve efficiently or supersede earlier versions as needed.

An early version of the MVS focused primarily on the display of raster data. However, the need to view simultaneously 2D

vector plots as well as 3D images became apparent. Currently, a 3D model of Alaska is available that can be rotated around a horizontal axis. In time, MVS will combine high spatial resolution satellite imagery with input from process-level models. This will be done to examine the temporal and spatial images of methane emissions. Jim Brass has high praise for Acevedo's computer model. "Through the MVS model, our data has taken a giant leap forward. Now we can take data and present it in a way that is easy to understand conceptually as well as technically. Characterizing the data set with the 3D display is a big boon to understanding [ecosystem] interrelationships."

Plans for the MVS include incorporating high spatial resolution TM data and the development of more detailed physical process models that should increase the accuracy of projections. The increased demands, however, will mean that the MVS will be incorporating massive amounts of data into the simulations. As Acevedo points out, "A typical scene may represent three-hundred megabytes of data. Perhaps twenty of those scenes are needed to represent one day's worth of data. If we assume a ninety to one-hundred day growing season, well, we're getting into terabytes of data. We're exploring the development of distributed processing with the Central Computing Facility here at Ames. Eventually, we hope to be able to run a simulation on the Cray-YMP™, and then examine the results on our workstations." For now, the MVS prototype continues to evolve, meeting the increasing requirements of researchers at NASA Ames Research Center and their mission to planet Earth.

Based in the San Francisco Bay Area, Gaye L. Graves is a freelance writer who specializes in computer graphics, animation and special effects.

Image: Four satellite images of Alaska from an animation sequence depicting vegetation condition over the growing season (June, July, August and September). These data are used in modeling regional methane emissions.

BOTH SIDES NOW

3D graphics
give scientists
a new angle
on cloud formation and the
relationship of
clouds to
global warming.

BY CYNTHIA M. MARSHALL

When Judy Collins crooned, "I really don't know clouds at all," in a popular 1970s ballad, little did she know that climatologists around the world were echoing her sad refrain. Until recently, these ethereal shapes eluded even the most dedicated in the field — at a time when such knowledge is critical to our environmental well-being.

Learning more about clouds is the charter of the Center for Clouds, Chemistry and Climate (C⁴), located at Scripps Institution of Oceanography. A recent study co-authored by the Center's director and one of its researchers suggests that clouds may play a vital role in controlling global warming or the greenhouse effect.

What is the greenhouse effect — really?

The potentially disastrous consequences of the greenhouse effect have received a lot of attention lately. It is important to understand, though, that the greenhouse effect is a naturally occurring process that helps the Earth's surface maintain a relatively stable temperature. Stated as a simple equation, the greenhouse effect can be expressed as the difference between the amount of radiative heat emitted by the Earth's surface and the amount emitted by the top of the Earth's atmosphere.

Without a greenhouse effect, the Earth's climate would suffer dramatic extremes in temperature, much like those of the

Moon's, which has extremely hot days and severely cold nights.

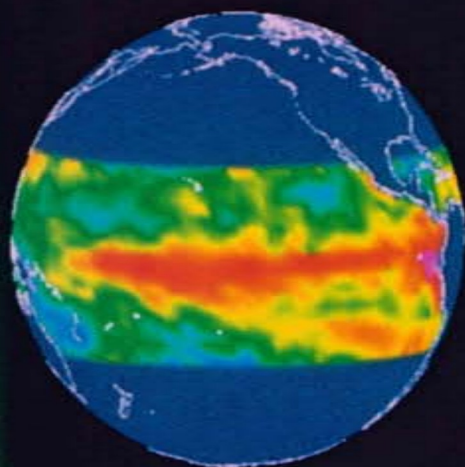
Scientists know that the greenhouse effect increases as the Earth's temperature increases. What they do not know with absolute certainty is whether a large increase in the Earth's temperature might cause an unnatural, "super" greenhouse effect — one that could spin out of control and make the Earth's climate inhospitable to life.

A naturally limiting mechanism

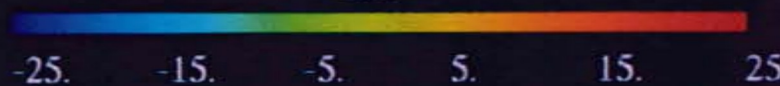
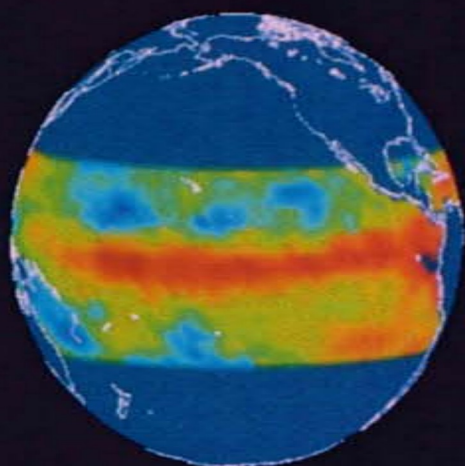
To better understand the impact of temperature increases on the greenhouse effect, Dr. Veerabhadran Ramanathan, C⁴'s director, and a colleague, Dr. Bill Collins,

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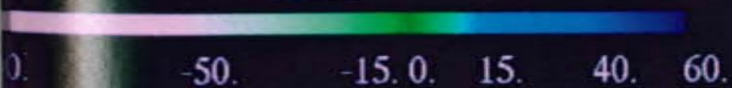
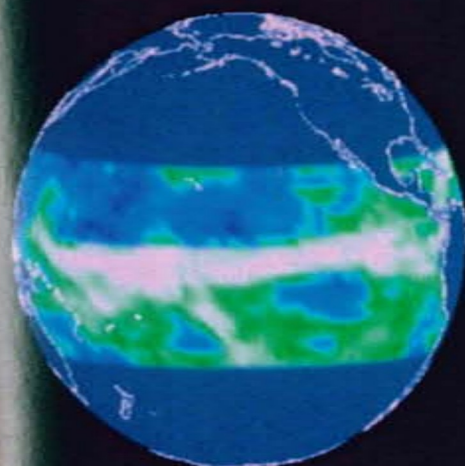
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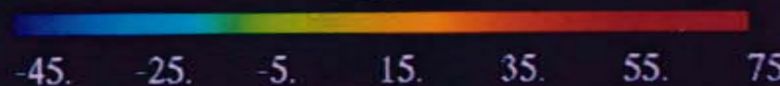
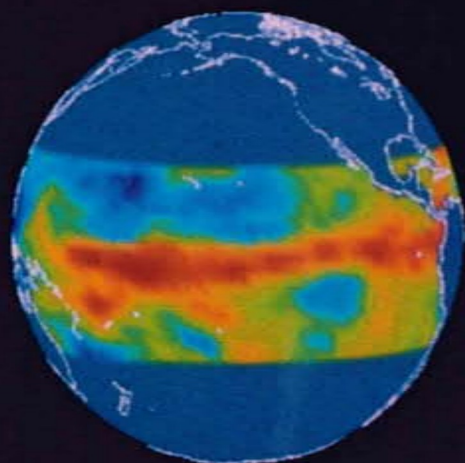
Atmospheric Greenhouse Effect (W/m^2)

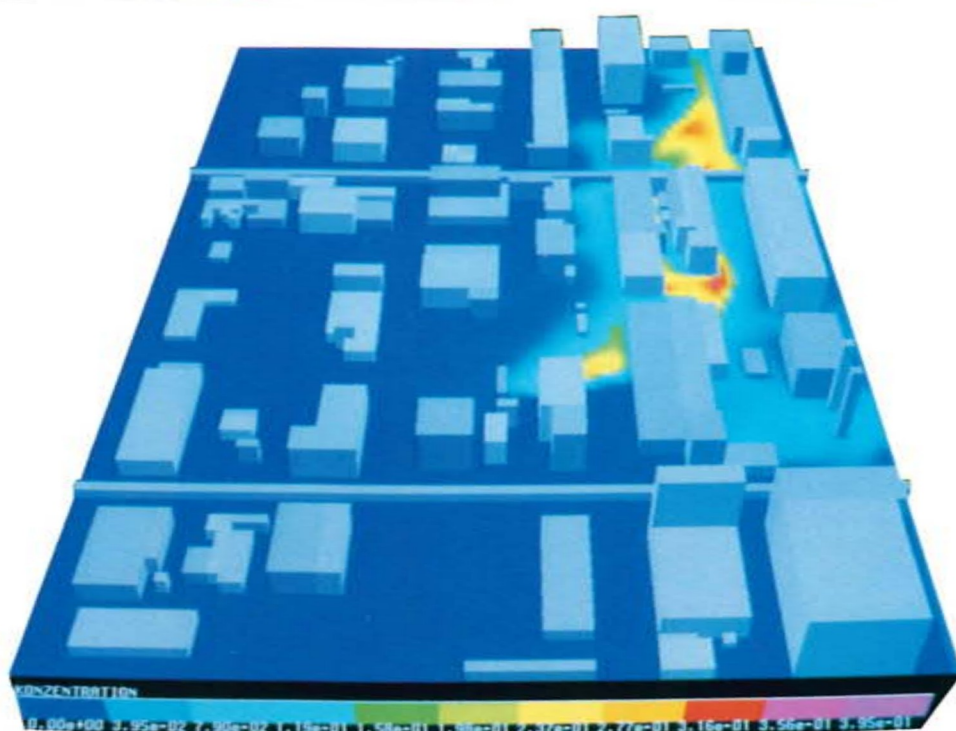


Shortwave Cloud Forcing (W/m^2)



Longwave Cloud Forcing (W/m^2)





VISUALIZATION FOR ENVIRONMENTAL ANALYSIS

By Volker Kühn and Markus Groß

Protection of the environment is one of today's most crucial global issues, and European countries are especially aware of this. Past emphasis on rapid industrialization has created current problems of critical magnitude. The public and the government are concerned that industrial pollution is overlapping areas of dense urban population. Newly proposed factory complexes, as well as restorations of earlier large scale industrial installations, are now coming under careful scrutiny.

A computer graphics research and development group in Germany has been working to create software with universal application as a visualization tool for environmental purposes. This group, the Computer Graphics Center (ZGDV), was established in 1984 to develop application-oriented training, research and development in the field of computer graphics. The laboratory at ZGDV is equipped with one Silicon Graphics 4D/310 VGX and one 4D/380 VGX, along with two IRIS Indigos and six Personal IRISes, including one 4D/35 and five 4D/25s. Silicon Graphics' IRIS Graphic Library (GL) is used for visualization.

ZGDV, the Technical University of Darmstadt (THD-GRIS), and the Fraunhofer Computer Graphics Research Group (FhG-IGD) comprise "The House of Computer Graphics," one of the world's leading computer graphics collaborations. In total, the Research and Development center at the "House of Computer Graphics" boasts of more than fifteen PhDs, one-hundred researchers with MScs and thirty technical and operational staff members, all supported by two-hundred-fifty BSc and MSc students. They work with an annual budget of \$12 million (U.S.) in the main areas of computer graphics research and development. Projects under study involve post-professional education, graphical user interfaces and their applications, computer simulation, image analysis, computer vision and multimedia interaction techniques.

Although the CPU power available today makes it possible to use numerical environmental modeling techniques that can be applied to the calculation of pollution distributions, efficient visualization methods and sophisticated pre- and post-processing

tools are necessary to produce qualified data for environmental analysis. Recognizing this, ZGDV developed a software package called TERRA™.

Designed to handle terrain data processing and management as well as visualization of environmental data, TERRA simulates the pollution distribution behavior in the atmosphere. Its main applications are in the areas of environmental research, pollution behavior and air quality analysis. TERRA can be used as an extension to a commercial geographic information system (GIS) or as a stand-alone tool box for applications including license and permission procedures, restoration of large-scale industrial installations, forest damage analysis, safeguard coordination and pollution distribution forecasting.

The TERRA system consists of a scene editor, an image classification tool, a computer vision tool, a digital terrain model, a simulator and a visualization tool. TERRA performs real-time applications, and its high-performance communication interfaces support a fast data transfer between

system components. TERRA's user interface is based on X-Windows and OSF/Motif. This interface gives the user a high level of interactivity, such as flight and navigation over the terrain in question.

Air Pollution Modeling

A real concern in the creation of an accurate pollution distribution specification is the exact modeling of the air flow, or wind field, over the terrain in question. First, the local 3D wind field must be calculated from the global wind direction and speed, taking the terrain into account. Next, the local wind forces are applied to the pollution particles moving through the wind field. This particle movement, determined in every position in space, results from the wind force, the particle interactions with neighboring particles and external forces.

Distribution calculation of pollutions is divided into three model types that cover different terrain sizes. Micro-scaled models, meso-scaled models, and macro-scaled models that are further classified as either prognostic or diagnostic. TERRA uses a diagnostic micro-scaled wind model for pollution analyses on factory campuses or in cities. The system also uses the prognostic meso-scaled wind model for long-term analyses and forecasts of pollution in cities, their suburbs, landscapes and other wide areas.

The complete simulation procedure is performed via a two-pass process which first calculates the 3D velocity field and then distributes particles into the atmosphere. Particle distribution is determined by the velocity field and other external forces included in the meteorological model used. Post-processing then makes it possible to obtain the actual concentration of the spatial and temporal air pollution. Pollutants most often under environmental scrutiny include those emitted by factories, industrial plants and traffic (ie. land vehicles and aircraft).

ZGDV is exploring further and more complex applications for TERRA, such as the chemical reaction behavior between pollution particles with respect to atmospheric layers, in addition to the determined discrete wind field. Along with greater realism, this increase in complexity will allow, for example, analysis of the concentration development over time of a specific chemical substance (pollutant), and over complex terrain and the aerosols in different atmospheric layers. Such future applications will be limited only by the power, speed, and accuracy of the enabling technology.

Mark Groß is head of the Department of Computer Visualization and Image Analysis at the Computer Graphics Center.

Volker Kühn is the senior developer for the Department of Computer Vision and Image Analysis at the Computer Graphics Center.

For more information, contact: Volker Kühn; Computer Graphics Center (ZGDV), Wilhelminenstr. 7, 6100 Darmstadt, Germany.

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Ramanathan and Boer's cloud reconstruction program illustrates the connection between cirrus clouds and the storm clouds that produce them.

studied El Niño. At the beginning of El Niño, which happens every four to six years, tropical wind patterns change, moving warm water from the Western Pacific eastward to the Central and Eastern equatorial Pacific.

Using data collected by satellites from the Earth Radiation Budget Experiment (ERBE) and the National Oceanographic and Atmospheric Administration (NOAA), Ramanathan and Collins studied the sea's surface temperature, the greenhouse effect, and clouds from the start of El Niño's activity in April, 1985 to the end of its cycle in April, 1989.* During this time, the ocean's temperature increased from its average temperature of eighty degrees Fahrenheit to almost eighty-six degrees.

"We found that when the ocean's temperature increases to above eighty degrees Fahrenheit, the greenhouse effect accelerates rapidly. However, the climate remains stable, despite this enhanced greenhouse effect. For us, the big question was 'How does the oceanic/atmospheric system remain stable?'" Ramanathan explains.

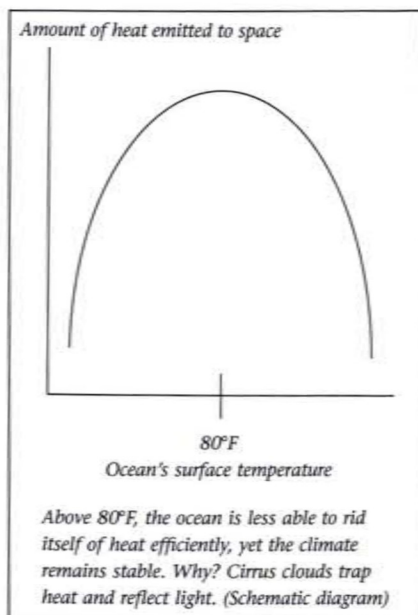
* The satellites provided measurements of sunlight coming into the Earth; sunlight reflected back out by the Earth's surface, clouds, and the atmosphere; and heat emitted by the Earth's atmosphere.

The answer? Clouds. Cirrus clouds — the white, wispy clouds found at high altitudes — are an indirect product of the atmospheric circulation that results from the high ocean temperatures. These clouds trap heat and — much to the researchers' surprise — also reflect a considerable amount of sunlight. By reflecting light, the cirrus clouds shield the ocean from sunlight, which cools both the ocean and the rest of the atmospheric system as well.

3D graphics were instrumental to establishing this conclusion. While the data

supplied by the satellites was exactly what the researchers needed, finding a way to systematically handle all of it was a challenge. In total, the researchers had almost eight gigabytes of data to process.

Without a greenhouse effect, the Earth's climate would suffer dramatic extremes in temperature, much like those of the Moon's, which has extremely hot days and severely cold nights.



Using the IRIS Graphics Library's™ (GL™) quadrilateral strip feature, Collins was able to turn this quagmire into a computerized, 3D globe. By adding a spaceball to the system, the globe could be rotated and moved on three axes.

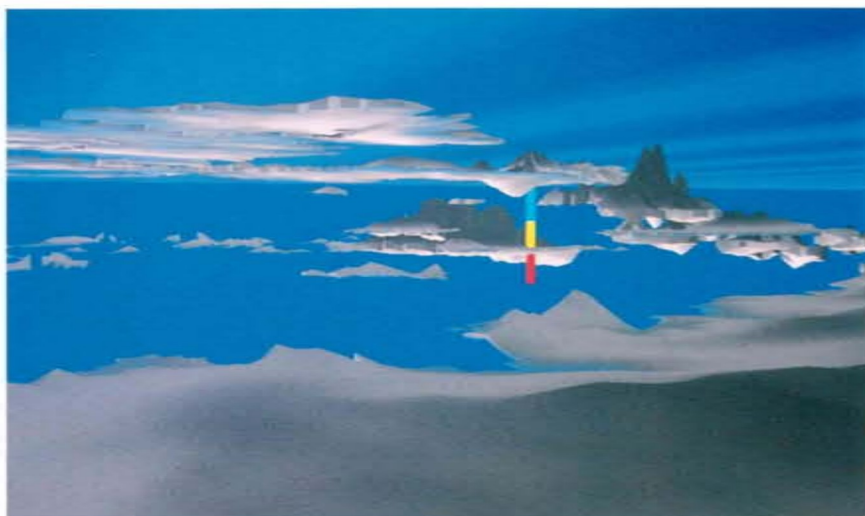
Advanced graphics technology also made it easier for Ramanathan and Collins to stay focused on the data most relevant to their research. "Because we could represent the ERBE and NOAA measurements accurately as a three-dimensional globe, we weren't swamped with data. Working with the IRIS 4D/340, we could view activities, say, in the Pacific Ocean, then spin the globe to see the immediate impact on the Indian Ocean, and so forth. In other words, we could better see the trees from the forest," says Collins.

Pondering clouds further

Knowing the significance of cirrus clouds relative to the global warming process has given way to further study of the clouds. To foster a more sophisticated understanding of them, Ramanathan and a protégé, Erwin Boer, are developing a tool that constructs 3D images of the clouds. The program they are developing reads data extracted from infrared and visible images of the Earth taken by satellite. It then combines that data with known information about the properties of clouds to arrive at a plausible model of a cloud.

"I've been pleased with what we've learned from this tool," says Ramanathan. "For the first time, we've been able to look at cloud reconstructions dynamically and in three-dimensional color animations, instead of staring at tables of numbers and line graphs. This marriage of satellite data and visualization techniques will enable us to learn the essentials of cloud physics, just as the visualizations that we applied to the El Niño data made it possible to evaluate the greenhouse effect in a new way," he explains.

"Being able to render polygons rapidly using the IRIS GL™ has been key to our early



The cloud reconstruction program highlights the cirrus clouds' extensive coverage. Because these clouds cover thousands of square kilometers, their reflective and heat-trapping properties are significant.

successes with this program," adds Boer, the program's primary designer and coder.

When completed, the program is expected to aid scientists during experiments and provide a more accurate picture of exactly how clouds are formed.

What it all means

While Ramanathan and Collins' work might seem to contradict the predictions of worst-case greenhouse effect theorists, the pair's message is not much rosier. Rather than proposing the possibility of a runaway greenhouse effect, one of the things that Ramanathan and Collins suggest is that a significant increase in the temperature of the tropical Pacific Ocean — to, say eighty-nine degrees Fahrenheit or greater — would probably signal a change in climate. If their thermostat hypothesis continues to hold in a changed climate with warmer oceans, regional climate patterns might be significantly affected.

On a more positive note, Ramanathan and Collins have broken considerable ground in providing those who follow them with a predictable baseline for future work — a framework that did not exist before. As anyone who has ever relied on the news for an accurate weather forecast can attest, the science is inexact at best.

Would all of this have been possible without advanced, 3D graphics? Perhaps, but it would have been less precise and considerably more time consuming. "A key to getting through the data was testing and rejecting hypotheses quickly. 3D graphics allowed us to do that; we could flash through a lot of possible explanations quickly," says Collins. "I don't think we could have gotten the science done without being able to visualize it," he says.

The Center for Clouds, Chemistry and Climate is housed on the campus of the University of California at San Diego (UCSD). It brings together research groups in the United States, Germany and Scandinavia that have made fundamental contributions to a number of cloud-related areas, including global warming, atmospheric chemistry, climate and global change.

The Center uses a Personal IRIS 4D/20, an IRIS 4D/340 VGX, NCAR National Center for Atmospheric Research (NCAR) graphics, and proprietary visualization and analysis tools developed using GL and the IRIX™ operating system.

Cynthia Marshall is a freelance writer based in Mountain View, California.

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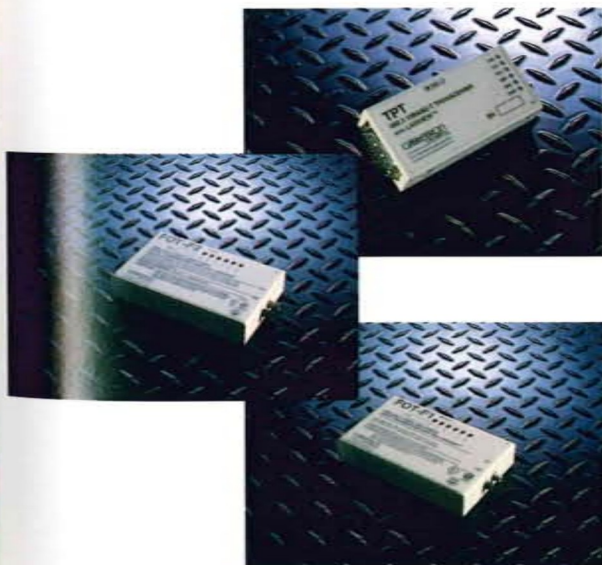
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Building a New Doorway to the World

In the near future, there will exist a new kind of world atlas that will allow armchair explorers to go much farther and with greater knowledge than their backpack toting predecessors could have dreamed.



By Douglas Cruickshank

If, as is so often said, we are dwelling in the age of information, then the future will almost certainly belong to those who can figure out an effective means for making sense of what this epoch has left us enough data to fill the oceans and canyons and envelop the mountains (and more coming every nanosecond). As our ability to acquire and categorize information accelerates, old methods of storage and retrieval must give way to new — thus the invention of the microchip and the computer. One of the most significant byproducts of the computer's introduction has been the revitalizing of old informational media into new, amplified, more relevant forms. One such metamorphosis is currently underway: the creation of an interactive, three-dimensional world atlas for users of IRIS workstations.

With the possible exception of Atlas himself, the titan of Greek mythology who was condemned to support the Earth on his shoulders, perhaps no man feels the weight of the world as literally as Brad de Graf. Mr. de Graf's company, de Graf Associates, a Los Angeles based consortium concerned with innovative uses of electronic media in education and entertainment, has recently completed the initial prototype/proof-of-concept for something called the Electric Atlas™. As de Graf describes it, the Electric Atlas "allows users to interactively rotate a three-dimensional computer-generated 'virtual' globe on a high-resolution screen. The user controls a window on the globe to define a region of interest, which can be any latitude-longitude bounded rectangle on the surface of the Earth to the limits of the resolution of the underlying database. Once a region of interest has been chosen, a terrain model is created by accessing global elevation and ground color databases."

In other words, what de Graf intends is not merely to put the whole world in our hands, but to place it right at our fingertips. By using real-time 3D graphics, the Electric Atlas, which, at present, runs exclusively on the Silicon Graphics platform, will make it possible to explore a world's worth of highly accurate terrain models. The terrain models can be explored interactively with a variety of display options available,

such as cloud cover overlays, changes in the time of day or season and political boundaries. In future editions of the Electric Atlas, de Graf plans to offer active features on the terrain model, for example, icons that set off video, text and sound displays germane to the politics, culture or ecology of the region being explored.

de Graf credits Kevin Kelley's sumptuous book, *The Home Planet* (Addison-Wesley, 1988) with inspiring his idea for the Electric Atlas. In early 1991, de Graf was serving as creative and technical consultant for the Home Planet Exhibition, an installation based on Kelley's book, which will open at the United Nations in June of 1992. "We were all interested in using interactive electronic media to make the exhibition more dynamic," de Graf recalls. "In the process of figuring out how

to do that, the concept gelled in my mind — an interactive system for exploring Earth-related information electronically that anyone could feel as comfortable using as they do a book." The concept became a prototype project for Silicon Graphics. Developed with IRIS Explorer™ on an IRIS 4D/310 VGX workstation, the Electric Atlas was first displayed at SIGGRAPH '91. Formerly a principal in de Graf/Wahrman, a Los Angeles company that created theme park installations and computer animation for feature films (they did the impressive 3D title sequence for *The Jetsons* movie), de Graf has been using Silicon Graphics workstations for nearly ten years. "We started way back with the 1400 workstation," he recalls. "Silicon Graphics is clearly the leader in high-performance computing, and has been for the last decade. There's really no substitution."

THE GEOSPHERE PROJECT

Another important affiliate of the SAVE program, the GeoSphere Project, under the guidance of founder and Executive Director Tom Van Sant, is pursuing a multi-phase program aimed at making complex global systems understandable. As Van Sant is a strong believer in the importance of visualization, it is appropriate that one of the organization's most impressive accomplishments to date is the GeoSphere Image, an extraordinary, I've-never-seen-anything-like-this-before, composite satellite picture of the Earth, cloud free, as viewed from an altitude of five-hundred-twenty miles. The image that adorns the title page of the 1990 *National Geographic Atlas of the World* and is also available as a poster, took ten months and \$600,000 to reach completion in April of 1990. The picture was created by assembling data gathered by Advanced Very High Resolution Radiometer satellites operated by the National Oceanic and Atmospheric Administration. A new, even higher resolution GeoSphere Image is now in development.

In the fall of 1990, Van Sant and company completed work on the six-and-a-half-foot-in-diameter GeoSphere Globe and are now developing the capability for projection of live weather patterns onto the sphere via direct transmission from global weather satellites. The ambitious group is also working on the integration and co-registration of the Earth systems global databases for their Global Visual Library, and to complement the co-registration of the World Topography Database and World Data Bank II — work that the organization has already completed.

In the spring of 1992 the GeoSphere Project will complete the first of several Earth Situation Rooms. Each room will contain eleven workstations configured in a circle around a GeoSphere globe sixteen feet in diameter. These facilities, seen as the Project's "final product," are planned as part of a world wide network that will "receive, process and disseminate visualizations of the Earth's global database information to education, media, publishing and electronic forums," all for the purpose of better understanding and managing the Earth's resources.

For more information contact The Geosphere Project, 146 Entrada Drive, Santa Monica, California 90402.

In its final form, the Electric Atlas will be based on two major databases and several smaller ancillary databases. One of these reservoirs of digital information contains elevation figures for the entire world. The second is a one kilometer resolution database containing information about ground color around the world. "At present," de Graf says, "The state of the art is a single pixel for each square kilometer, which means that every square kilometer on Earth is represented by one color. Obviously, the color is an average because there are few, if any, places on Earth where the ground color is the same for a square kilometer, but in most cases it's a good representation."

The richness and precision of the global image, as viewed by a user sitting at his IRIS

...what de Graf intends is not merely to put the whole world in our hands, but to place it right at our fingertips.

workstation, will be largely dependent on its underlying data. In creating the atlas, de Graf has used a global digital image generated from a database provided by Global Vision Systems (GVS), a Bolinas, California company founded by Kevin Kelley, creator

of *The Home Planet*, and Robert Johnston. "GVS defines the state of the art in global digital information derived from satellite-borne remote sensors," de Graf says, "and they will continue to improve the quality of their information, particularly as the Earth Observing System (EOS — NASA's system of observational satellites that will go into service in the late 1990s) comes online and techniques for interpreting their data become more sophisticated."

After listening to Brad de Graf it is difficult to resist his enthusiasm for the apparently limitless possibilities of the Electric Atlas project. de Graf thinks the Electric Atlas can combine the best qualities of book atlases and traditional world globes. "We're using technology to create a doorway to informa-

GLOBAL VISION SYSTEMS

Apart from Edward Steichen's classic *Family of Man*, there is no other book to which Kevin Kelley's *The Home Planet* can be easily compared. While the two large format books differ in subject matter, they possess a similar spirit and share a common intent: to inspire. They are similar in other ways as well. Neither Steichen nor Kelley authored their books, both of which became best sellers. Instead, they conceived of the themes and edited the words and pictures of others. *Family of Man* is a compilation of photographs of the world's people coupled with well chosen quotations. *The Home Planet*, on the other hand, is a collection of pictures of the world itself — photographs taken of the Earth from space — accompanied by the thoughts of astronauts, cosmonauts and other "space fliers" of the last thirty years. A stunning commercial success, *The Home Planet* also succeeds as a work of art. It has been translated into sixteen languages and spent six weeks on the *New York Times* bestseller list.

As Kelley explains it, "to take the vision of *The Home Planet* one step further" he joined forces with British artist Robert Johnston to create a true picture of the whole Earth. The now familiar photograph of the globe made during the Apollo 17 mission is not a picture of the whole Earth, Kelley points out, but rather of the "full Earth" (like full moon) — the whole Earth, most agree, is spherical not flat. "The problem up until fairly recently," Kelley commented in a telephone conversation, "was that what you could imagine was years away from what you could actually do, or if you could do it, it would take a tremendous amount of time. Now, rushing over the horizon is the technology to create what you can imagine right now. Certainly Silicon Graphics workstations are at the forefront, particularly if you're dealing with imagery and most particularly if you're working with three-dimensional imagery."

To create their whole Earth image, Kelley and Johnston needed a vast database of satellite pictures of the Earth. "It's extremely important to us that

the data be scientifically accurate," Kelley says. "To ensure that we teamed up with Dr. Peter Muller of University College, London." The database of satellite images of the Earth, that Muller — his Ph.D. is in Earth sciences — manages, originated at the school, and Johnston and Kelley have licensed it. They in turn have made the data available to de Graf Associates for use in producing the Electric Atlas. "Our focus is on scientific accuracy, but we also want this image to look as real as possible. We're interested in creating both a cloudless image and one that more closely approximates the Apollo 17 picture — with clouds and haze." Kelley stresses that while the whole Earth image will be of great value to scientists, it will be equally valuable as a source of inspiration. "What we tried to do with *The Home Planet*," he explains, "was inform people and, at the same time, inspire them."

In addition to the Electric Atlas, Kelley feels that the database could be a seed for scores of diverse applications. "I believe our group is primarily driven by the inspirational quality of this project. At the same time we do not want to be merely an image bank. We're particularly interested in applications. We realize that products need to be created and that there is a lot of opportunity."

In November, GVS successfully produced its first proof of concept demo at Silicon Graphics' Applications Laboratory in Mountain View, California. "There's no way we could do what we're doing except on Silicon Graphics workstations. The company — both its corporate culture and the individuals there — has been extremely supportive, encouraging and helpful, both from an inspirational point of view and from an ecological one."

"Global Vision Systems is really a communication company, a group of people," Kelley concludes, "using imagery and information to communicate in a way that informs and, hopefully, transforms."

tion, a doorway that did not exist before," he says. "In the past, one doorway was a book, that can contain a great deal of information but doesn't have the intuitive elegance of a globe; the globe was another type of doorway. In combining the two you have the intuitive sense of the globe being a sphere, so you can always know where you are, see the interconnectivity of all things and the finiteness of the Earth itself. Yet, because of the electronic access to vast, interlocked databases the amount of information at your command is unlimited; the portal is almost infinitely expandable."

de Graf believes that one important task before him and others involved in projects dependent on co-registering of global data — such as the GeoSphere Project and Global Vision Systems (see sidebars) — is to establish a set of standards whereby information, that comes from a variety of sources and in numerous forms — text, animation, audio, still and moving images — can be easily coordinated.

Like the twenty volume *Oxford English Dictionary* or the *Encyclopaedia Britannica*, the creation of the Electric Atlas may be a daunting task in itself, but the thought of keeping it up to date and accurate is overwhelming. de Graf stresses that the Electric Atlas is intended to be a process more than a single, one release product. "It's a series," he says, "a publishing venture. Things change, you know. In fact that's one of the most exciting things about the idea — here is an atlas that can change right along with them." He points out that the Electric Atlas would not have been subject to the turmoil experienced recently in the cartography, atlas and encyclopedia businesses due to the socio-political revolution in Russia. "Something like that could be dealt with in a matter of hours and a new version of the Electric Atlas distributed to users," he comments. In the future, de Graf would like to distribute the atlas via fiber optic networks. "Then subscribers could get updates almost immediately."

Though he has not yet announced a release date, de Graf says a first version of the Electric Atlas is not far off. His principal concern is in producing something everyone can use. "I want to get it into the hands of the public," he says, "which means it must have a good set of functionality and performance features. The concept is based on interactivity: it allows novice users to interact with an elegantly organized interface and extract any information they desire. That's the beauty of it. So much of what humans do is multi-connectional. You can't ask for a better example of that than the Earth. In a sense the Electric Atlas iconifies a massive amount of information into that single, three-dimensional form — a sphere — and lets the user dive in. Over the next ten years," de Graf continues, "this society is going to be overwhelmed with information. We need to abstract that information into forms that can be grasped quickly. The Electric Atlas is one very good way to do that."

For more information on the Electric Atlas, contact de Graf Associates, 1328 Maltman Avenue, Los Angeles, California 90026.

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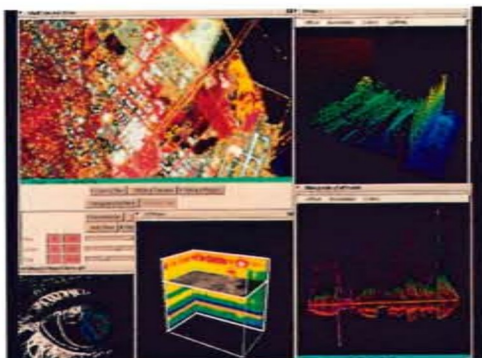


VISUALIZATION SOFTWARE



**SILICON GRAPHICS CONTINUES TO PROVIDE SOFTWARE
SOLUTIONS THAT ENABLE PROGRAMMERS AND USERS
TO VISUALIZE SCIENTIFIC DATA.**

By Bill Pickering with Anne-Marie Gambelin



How often have you wished that you could modify your application to help you understand an elusive facet of your data, or follow a hunch? Silicon Graphics has a history of providing solutions so that you can. Users frequently have some component of software development in research, because coding requirements for visualizing data are unique to specific scientific problems. Silicon Graphics provides tools and libraries that release users from continually having to reprogram and reinvent algorithms. With the visualization software development environment at Silicon Graphics, programmers and users alike can visualize scientific data—quickly, so as not to stem the flow of the creative tide. Silicon Graphics provides tools that make workstation technology transparent, so users can concentrate on application science and not computer science.

Recognizing the need for users to have the same versatility and functionality as their programming counterparts, Silicon Graphics provides a software development environment that spans the abilities of programmers and users, embodying relational layers of development software from flexible, low level programming to high level application programming. Programmers may delve into the high performance 3D graphics routines of IRIS Graphics Library, or develop image processing applications with ImageVision Library. Additionally, Silicon Graphics' CASEVision provides productivity tools to assist programmers in debugging and performance analysis of their IRIS Graphics Library and ImageVision Library code. Blurring the line between programmers and users is IRIS Explorer, a dynamic user-definable modular application builder. Layered upon one another, these software development applications leverage the capabilities of their bases, creating a synergy that yields greater productivity and ease of incorporating new workstation technologies.

The foundation of Silicon Graphics' software development environment is IRIS Graphics Library, a sophisticated set of graphics programming routines that en-

able programmers to transform 2D and 3D graphics data into visual computing applications. Providing and improving graphics functionality and flexibility, programmers can access more than four-hundred-fifty IRIS Graphics Library functions to build realistic, interactive 3D applications. Graphics primitives such as points, lines, polygons and meshes form the basis for photo-realistic 2D and 3D graphics and animations, including such advanced features as hidden surface removal, anti-aliasing, Gouraud shading, light sources, transparency and texture mapping.

An evolution of the market leading IRIS Graphics Library, OpenGL is rapidly emerging as a truly open graphics standard. With more than 1500 existing applications, OpenGL has the largest base of software applications of any 3D graphics application programming interface (API). OpenGL is a rich, mature 3D graphics API that allows PC and workstation software developers to create applications for visualizing and manipulating 3D graphics. Silicon Graphics announced last fall the availability of OpenGL for general licensing to the industry. Since then, twelve industry leading companies including Compaq Computer Corporation, Digital Equipment Corporation, Intel Corporation, Microsoft Corporation, Du Pont Pixel Systems Ltd., IBM Corporation and UNIX System Laboratories have licensed OpenGL from Silicon Graphics.

Similar to IRIS Graphics Library, Silicon Graphics offers ImageVision Library, a programmer oriented image processing tool kit that allows users to do image processing — without having to write routines — by way of a core set of image processing functions. More importantly, since developers must work with a broad range of image processing algorithms, ImageVision Library is designed to simplify the extension of the standard function set to suit specific application needs. ImageVision Library's tiling mechanism breaks up the image into sub-images and provides many benefits to an image processing application by allowing access to images as flexible, rectangular memory pages. Additionally, Image Vision Library's

pull-model feature enables the workstation to process data upon demand, allowing an application to quickly process only the area of interest or the interactive modification of application parameters. The immediate benefits of these two main features are reduced memory overhead and I/O processing time, improved system performance and maximized application throughput.

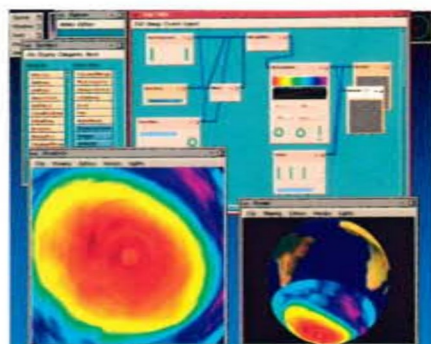
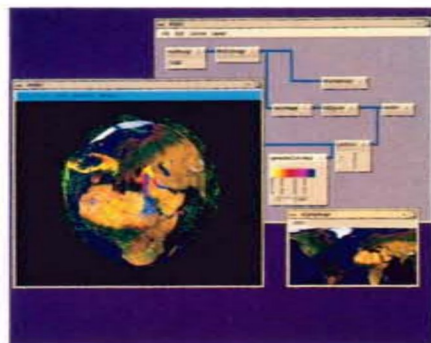
IRIS Graphics Library and ImageVision Library provide programmers with a consistent API across the Silicon Graphics product line. By providing a consistent interface across various hardware configurations, Silicon Graphics can provide solutions in a wide range of price/performance levels. Furthermore, a consistent interface allows Silicon Graphics to continue to design faster performing workstations and graphics subsystems, while protecting software investments.

Just as workstation technology is continually evolving, so is software development technology — but at a slower pace. Many of the software tools available today were designed to handle small, single-process applications written in a single programming language. Users often work in large, heterogeneous, distributed environments and utilize multiple languages. In addition, modern applications incorporate multiprocessing, graphics and imaging, which are more complex to create and maintain. CASEVision provides solutions that are specifically designed to handle the inherent complexities of today's software development environments.

A major component of CASEVision is CodeVision, a set of tools designed to make programmers more productive by visually reflecting the structure in which they work. It consists of three unique tools in an integrated environment: the Static Analyzer source code analysis and navigation tool helps programmers visualize the structure of code; the source-level Debugger displays multiple graphical views that are updated dynamically during an application's execution; and, the Performance Analyzer provides an integrated collection of several tools that measure, analyze, and

help users improve application performance. Together, these provide a scalable, dynamic tool set that enables programmers to be more effective.

With CASEVision, users can develop the applications that are needed to process data. Rather than having to rewrite applications, users can recycle existing applications. Why reinvent the wheel? Histori-



cally, use of existing code was impossible due to the difficulties of integrating existing code into a new program. Through CASEVision's built-in features, users are able to construct new applications from existing applications that have been developed during various projects by different programmers, even written in different software languages.

IRIS Explorer consists of modules that can be mixed and matched and connected in a visual programming environment, the map editor, to build an application specific to a user's needs. Connections of these building blocks are created visually by

clicking the mouse on a widget within the module icon, then clicking the mouse on the module port to be connected. There are no predefined connections or sequences for the modules, which affords users flexibility — the flexibility of customization. And, modules can be just about anything, from data readers and format converters to isosurface generators, image processing algorithms, equation solvers and renderers. Additionally, modules may be constructed of many smaller modules or become a stand-alone application. After the user has connected modules together, the resulting application, referred to as a map, can be saved for recall later. When the map is saved, all of the parameter settings, text strings and layouts are saved as well, affording a logical endpoint from which the user may resume "programming."

With IRIS Explorer, users only need to connect modules together to create an application. However, users may desire modules that do not exist, in which case integrating code may be necessary. To do this, IRIS Explorer includes the Module Builder utility that allows users to build IRIS Explorer modules from code. An easy step-by-step process allows rapid integration of existing code into the IRIS Explorer environment. Once an application has been built into a module, it can be connected easily to other modules in the map editor. Thus, software written by one user can be connected as a module to another module from another user.

No longer will users be faced with having to reconcile incompatible file formats received from colleagues all over the world. Just as the Module Builder allows programmers to integrate code into IRIS Explorer, the DataScribe utility allows users to import various data set formats into the IRIS Explorer environment. DataScribe allows users to save data files into non-IRIS Explorer file types, enabling non-programmers to read and write data files from other applications, without having to write code or interfaces (wrappers) from one set of protocols to another. This is especially significant for users with large data sets that have been written in dissimilar environ-

ments and provides an opportunity for developers to share data that exist in hundreds of distinct and presently incompatible structures.

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Users of IRIS Explorer have the visual advantage, affording logic and insight into the intuitive visually integrated programming environment. Once a user has created a map, it is very easy to modify it to new specifications to extract additional information. For users, that is very important, because once something is understood about data, additional questions usually follow — questions that could not have been formulated without that understanding. Software development with IRIS Explorer is always dynamic. Users can create custom applications tailored to their needs, and then create a bookshelf of frequently used modules and maps that will put them right at their fingertips.

IRIS Explorer was architected from the ground up to run efficiently in a distributed execution environment. Any application can be constructed out of modules and then be executed on various workstations across a heterogeneous network — without requiring users to configure anything at all to communicate with different workstations. Users read-in modules from remote workstations to their local workstations as easily as they load and connect modules that run on their local workstations. Especially significant, this feature allows users

to run modules on networked workstations where they make the most sense, taking advantage of one workstation's power while exploiting the graphics capabilities of another.

Silicon Graphics, IRIS Partners, universities, supercomputing centers and research institutes are making IRIS Explorer modules available as either third party software packages or as Public Domain Software. As part of the focus on Earth and Environmental Sciences, Silicon Graphics is currently developing a means to facilitate the distribution of modules within that community.

Hardware features and technology will continue to accelerate and increase in complexity. Developers lag behind the technology, trying to understand and port to new hardware as it is made available. Historically, to take full advantage of continual hardware advances required weeks or months of user education and training. Silicon Graphics recognizes the need for comprehensive, flexible software development tools for timely leverage of new workstation technologies. Layered upon one another developmentally, IRIS Graphics Library, ImageVision Library, CASEVision and IRIS Explorer provide a comprehensive software development paradigm for heterogeneous environments. Integrated together, these tools are designed to allow quick and easy access to new workstation technologies. By making the application creation process both clear and intuitive, Silicon Graphics brings advanced workstation technology to the desktop and blurs the line between programmers and users.

For information about attending the Earth and Environmental Science/Visualization Seminars held throughout the United States, April 25 – June 1, please call your local Silicon Graphics sales office.

Bill Pickering manages the Earth and Environmental Sciences Market within Silicon Graphics' Advanced Graphics Division.

Anne-Marie Gambelin is the Editor of the IRIS Universe.

On Tuesday, January 28, 1992,
Silicon Graphics announced
the first MIPS R4000SC-based workstation
available anywhere.

IRIS Crimson



By Kevin Gorey

The IRIS Crimson™ product line fills a former gap in the IRIS 4D line of products that lay above the IRIS Indigo in performance but below the cost of the POWER Series. The IRIS Crimson is a desk-side system available in six graphics and one server configurations. All IRIS Crimson products come standard with the following elements:

- superpipelined R4000SC processor with a 50 MHz external clock (100 MHz internal clock)
- standard CPU memory configurations of 16 Mb, a maximum memory configuration of 256 Mb, and a price-reduced 64 Mb bundle
- internal SCSI disk capacity up to 3.9 Gb, external SCSI disk capacity of greater than 51 Gb, and external high-speed SCSI disk capacity of 35 Gb
- high performance I/O subsystem including four VME™ expansion slots, Ethernet, and two SCSI channels with disk striping support
- up to four optional FDDI network controllers.

Fully Binary Compatible

Binary code that runs on any Silicon Graphics IRIS 4D system will run without modification on an IRIS Crimson. The IRIS Crimson is also fully source code compatible. Recompiling (without modification) applications that run on a Silicon Graphics IRIS 4D system will generate new binary code that takes advantage of the R4000SC's

instruction set extensions. These extensions include 64-bit floating point load and store instructions.

IRIS Crimson System Architecture

As the speed of CPUs used in workstations increases, ever greater amounts of time are spent by the CPU waiting for data to be fed to it. This data may be coming from disk, from CPU memory or from second level cache. Since most deskside workstations offered in the industry today are faster CPU variations of a low-performance desktop architecture, limited data throughput is a serious factor in total performance.

In order to avoid this common pitfall, Silicon Graphics has designed the IRIS Crimson using the POWER Series product line as the design base. The POWER Series systems are full project supercomputers, with the memory and I/O throughput that these environments require. The IRIS Crimson

supports VME™ bus bandwidths of 28 Mb/sec and has four 9U VME slots for customer expansion. With striping techniques, users can obtain over 13 Mb/sec of IPI disk throughput into CPU memory. SCSI striping across two channels is supported internally in the IRIS Crimson. Finally, the graphics subsystem is tightly coupled and supports transfer rates of up to two megaver- tices per second.

The R4000 combines all elements of the CPU onto one chip.

Just as important, however, are the data transfer rates from CPU memory into the first and second level caches. Four propri- etary Application Specific Integrated Cir-

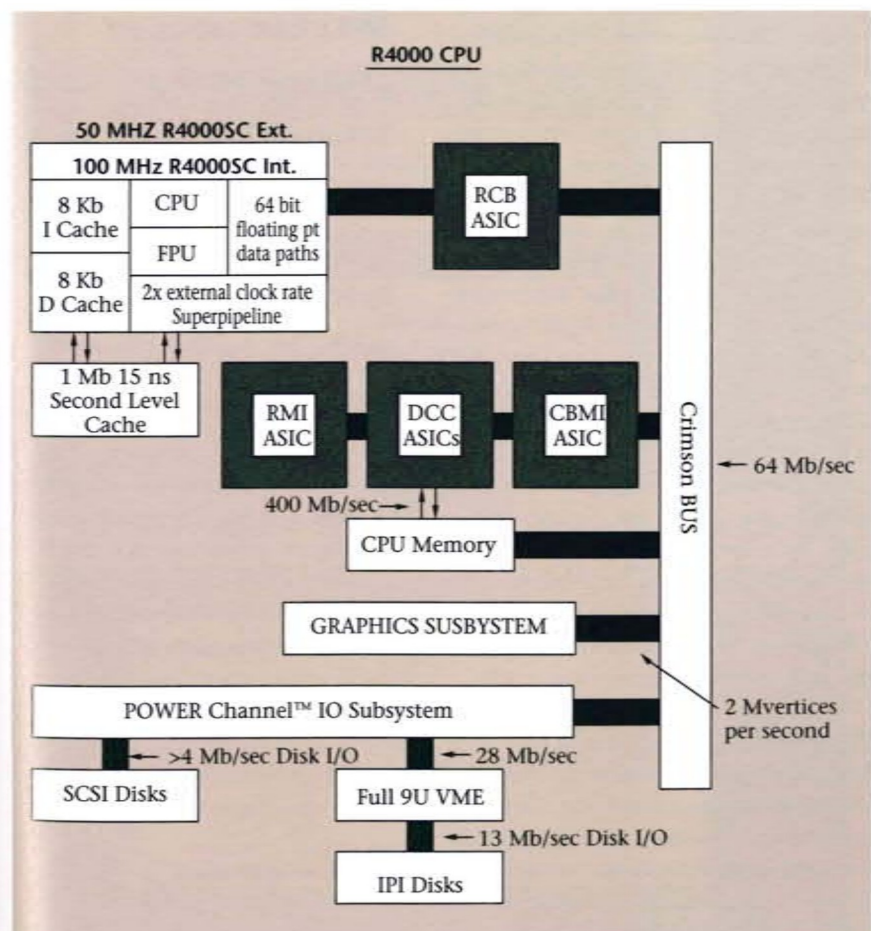
cuits (ASICs) were designed by Silicon Graphics to provide up to 400 Mb per sec- ond transfer rates from CPU memory to the R4000. This compares with a memory trans- fer rate in the range of 200 Mb per second for many commercial supercomputers.

The IRIS Crimson supports 16 Kb of first level cache and 1 Mb of second level cache. The second level cache is large enough to allow most applications to run in it without having to resort often to CPU memory. The second level cache memory speeds were substantially increased on the IRIS Crimson. The IRIS 4D/400 series, for example, uses 35 ns memories for its second level cache, while the IRIS Crimson uses 15 ns memories. This means that when the first level cache needs to be filled from the sec- ond level cache, the access times and data transfer rates are substantially reduced.

R4000 CPU

The heart of the IRIS Crimson is the new and revolutionary R4000SC version of the MIPS R4000 family of CPUs. One of the key bene- fits of the R4000 is that the CPU runs at 50 MHz externally, but 100 MHz internally. This means that one instruction enters the R4000 pipeline to be executed every 10 ns, allowing the chip to obtain MIPS and MFLOP ratings well above the speed one would expect for a 50 MHz chip. The R4000 is able to deliver this performance due to single chip implementa- tion with on-board first level caches, and the superpipeline structure.

A multichip CPU typically has first level caches and control logic spread across three or more chips. Both HP and IBM use multichip implementations in their desk- side workstations. As the designers push the MHz rates of these CPUs ever higher, the delays involved in transmission and latching, for example, become critical. The manufacturers must find parts that have extremely tight specifications and very high response times. These are generally both expensive and difficult to produce in quantity. It is estimated, for example, that to run an off-chip first level cache at 100 MHz would require 5.5 to 6.5 ns static RAMs, parts produced in low yields by a very limited number of suppliers.



R3000 INSTRUCTION PIPELINE

(5 Stages)

IF	RD	ALU	MEM	WB
----	----	-----	-----	----

IF	IS	RD	EX	DF	DS	TC	WB
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R4000 INSTRUCTION PIPELINE

(8 Stages)

A multichip CPU implementation limits the expandability of the CPU itself.

The R4000 combines all elements of the CPU onto one chip. The latching and transmission delays are eliminated. In addition, since the first level caches, for example, are on the R4000 itself and use the same advanced fabrication technologies as the R4000, the associated CPU circuitry is available from the chip vendors at the same time as the CPU itself is available.

The heart of the IRIS Crimson is the new and revolutionary R4000SC version of the MIPS R4000 family of CPUs.

The R4000 used in the IRIS Crimson runs externally at 50 MHz but takes advantage of the integration of all the critical pieces of the CPU to execute instructions internally at twice the external rate. As the R4000 moves to first 75 MHz external (150 MHz internal) and then to 100 MHz external (200 MHz internal), the key memory and control components will be guaranteed to move easily with it.

The second problem with vastly increasing the MHz rating of a chip is giving each stage of the compute pipeline time to complete before the next cycle begins. As the CPU clock rate increases, some stages of the

pipeline — especially those that read and write to first level cache — do not have enough time to complete within the cycle. One way to push the MHz rate of the chip ever higher is to further subdivide the basic pipeline. This technique is called superpipelining. The figure above shows the R3000 and R4000 pipelines.

A single R3000 instruction is broken down into five stages. First is the **I**nstruction **F**etch where the instruction is read in from the instruction cache. Second, the **R**ea**D** step reads in CPU information while decoding the instruction. Third, the **A**rithmetic **L**ogic **U**nit performs the instruction. Fourth, data **M**EMory references are made if the instruction involved a load or store. And, fifth, **W**rite **B**ack results of instruction into the appropriate general purpose register.

In the R4000 pipeline, the **I**nstruction **F**etch and the **I**nstruction **F**etch **S**econd-**H**alf stages each take one clock cycle and together perform the instruction fetch. The **E**xecute stage performs the instruction if it is one that does not require a load/store. The **D**ata **F**etch stage performs data cache translations for the load/store. The memory references are broken down into the **D**ata **S**tore stage that performs most of the data storage, and the **T**ag **C**heck stage that performs cache memory translations using the memory management unit.

There are two main compute optimization techniques used in workstations today: superscalar and superpipelining. Superscalar relies on duplicating the basic pipeline for specific functions. In the figure on the following page, the superscalar implementation contains three functional units. One

is for branch (which can perform one condition code instruction and one branch instruction simultaneously), one is for fixed point integer arithmetic, and one is for floating point arithmetic. Four instructions are read in during a clock cycle, and if those four contain one condition code, one branch, one integer, and one floating point instruction, then all four pipes can be filled simultaneously. This leads to a spectacular peak theoretical performance. When running real code, however, it is very rare, even using good optimizing compilers, that an application will consistently produce this mix of instructions. The actual performance on general purpose code falls well short of the peak theoretical rate.

The R4000 used in the IRIS Crimson runs externally at 50 MHz but takes advantage of the integration of all the critical pieces of the CPU to execute instructions internally at twice the external rate.

Superpipelining is a more general optimization technique. The superpipeline is relatively insensitive to the mix of instructions fed to it. It only cares that some instruction is ready at the end of each clock cycle. This means that a wider range of general purpose code will be able to approach the peak theoretical throughput of the R4000. Designers call this a wide "sweet spot" for it allows a larger number of applications to take best advantage of the CPU.

System Configurations

The IRIS Crimson/S™ is a CPU-only server configuration with no graphics. Despite its

low cost, the IRIS Crimson/S provides all of the platform advantages of the IRIS Crimson systems, including internal disk striping, large optional SCSI and IPI disk arrays, additional and multiple Ethernet™ and/or FDDI network controllers.

Silicon Graphics has designed the IRIS Crimson using the POWER Series product line as the design base.

The IRIS Crimson/Entry workstation uses the IRIS Indigo Entry graphics subsystem to provide a low-cost, high performance graphics capability for those who need the system primarily for computation and

only secondarily for display. The IRIS Crimson/Entry contains eight color bitplanes and supports 32-bit Z-buffering in software. Special hardware-assisted dithering with the Virtual 24™ color system produces high quality 24-bit screen images from the internal 8-bit color map. Screen resolution is 1024x768 with a standard 16" and optional 19" monitor. The IRIS Crimson/Entry is ideal for applications requiring high X Window, 2D vector or 3D vector performance. The IRIS Crimson/Entry also provides full GL™ graphics capability at very low cost to compute-oriented applications.

The IRIS Crimson/XS™, the IRIS Crimson/XS24™ and the IRIS Crimson/Elan™ are IRIS Crimson variations of the Elan graphics subsystem. Elan graphics combines not only outstanding polygon transformation and display performance, but also a feature set unavailable until now in a graphics subsystem priced this affordably. Each of the three new platforms that use

the hardware-based Elan graphics subsystem realizes significant 3D performance increases over the IRIS Crimson/Entry system that handles graphics processing in software. In addition, Elan graphics supports 1280 x 1024 screen resolution. The Elan graphics subsystem contains either one or four Geometry Engine™ (GE) supporting 3D graphics operations.

The IRIS Crimson/XS includes all Entry features, plus 1280x1024 screen resolution, optional hardware z-buffer, and one Geometry Engine processor to increase polygon performance.

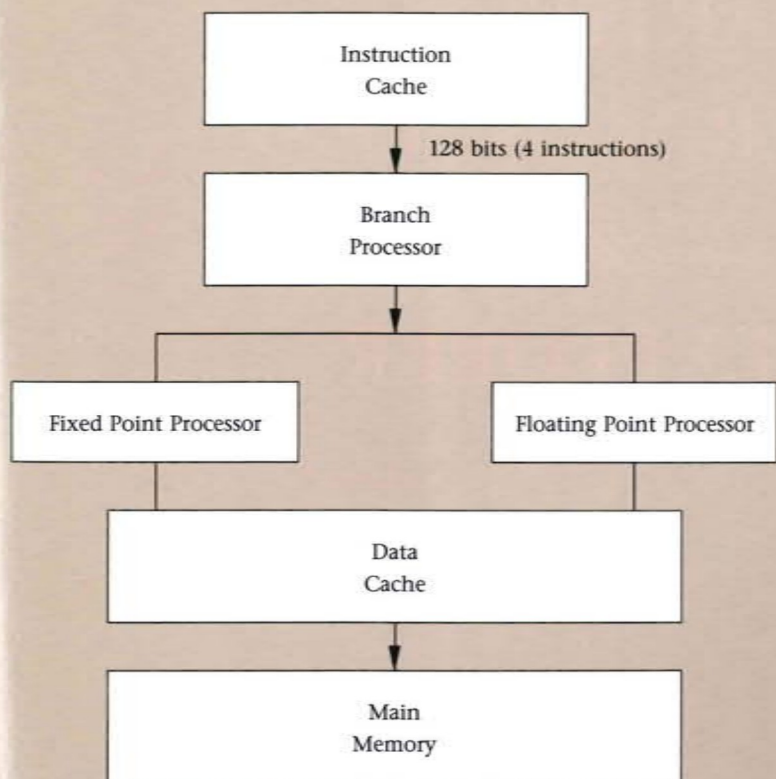
The IRIS Crimson/XS24 includes all XS features, plus 24 bitplane color. The Crimson/XS and /XS24 systems are well suited to compute-intensive applications requiring full color imaging or solids modeling capability.

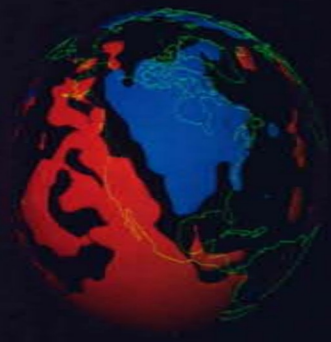
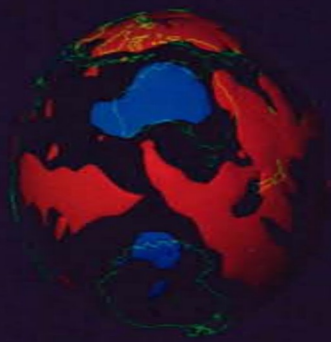
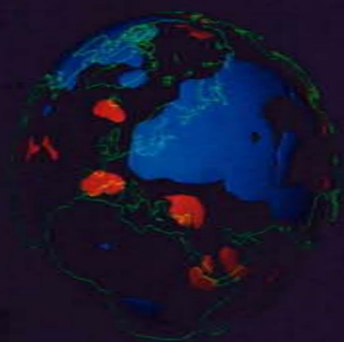
The Crimson/Elan includes 1280x1024 screen resolution, standard 24-bit hardware z-buffer, and four Geometry Engines. The IRIS Crimson/Elan delivers smooth screen motion of complex geometry, coupled with high compute performance.

The IRIS Crimson/VGX™ and IRIS Crimson/VGXT™ are based on the industry-leading POWER Vision™ graphics, delivering the fastest polygon performance available on any workstation, along with hardware-assisted anti-aliasing and texture mapping. The IRIS Crimson/VGX is the most powerful machine available for display of complex scenes and objects and is well suited to applications requiring limited texture mapping. The IRIS Crimson/VGXT is a low cost solution for compute intensive applications requiring complex texture mapping.

The IRIS Crimson product line is a major new offering from Silicon Graphics. The breadth of graphics supported, the power of the CPU and the performance of the entire system architecture, combined with very competitive pricing should cause the world to see crimson for quite some time.

Kevin Gorey is a Product Manager for Silicon Graphics' Advanced Graphics Systems.





VISUALIZATION
of the
EARTH'S
UPPER MANTLE
with
IRIS EXPLORER

P.J. Morin, T. Tanimoto, D.A. Yuen, and Y. Zhang

In the past few years, improvements in the technology of telecommunications and digital seismic networks have had a dramatic impact on global seismology. In particular, recent acquisition of seismic wave data from earthquakes with magnitudes greater than six has truly opened up new possibilities for geophysicists using tomographic inversion techniques to derive, for the first time, realistic 3D structures of the Earth's interior. The data set generated is quite complex and needs to be visualized adequately for geoscientists to understand better the dynamics of the mantle that are responsible for earthquakes and volcanic eruptions such as the recent event at Mount Pinatubo in the Philippines.

Thus far, most of the research in seismic tomography has been carried out using 2D seismic anomaly maps. Although this type of analysis can be carried out on workstations, the process is quite tedious and time consuming. Moreover, the full richness of 3D structures cannot be fully appreciated — even with many 2D cross-sections. There is need for faster model interaction and revision, which is possible by 3D visualization. In October, 1991, with the availability of the beta version of Silicon Graphics' IRIS Explorer software package, seismologists from California and the geodynamics group at University of Minnesota were able to visualize the 3D data set to be described. Since then, much more progress has been made.

The following illustrates the 3D images of the Earth's interior produced from the research completed by Professor Toshiro Tanimoto of the Seismo Lab at Caltech, Pasadena, California, and Dr. Yu-shen Zhang from the Institute of Tectonics at University of California, Santa Cruz. The visualization activities were carried out at the Minnesota Supercomputer Institute and the Graphics and Visualization Laboratory of the U.S. Army High Performance Computing and Research Center (AHPCRC) in Minneapolis, Minnesota.

Seismic Tomography

Geophysicists use seismic waves to probe

the interior of the Earth. This is similar to remote sensing. Global seismic tomography is a technique akin to medical imaging techniques in that information about the interior of an object is extracted by taking measurements on the exterior. Data were collected from large earthquakes with magnitudes of approximately six or larger. With the current state of technology, seismologists can detect seismic waves generated by earthquakes with magnitudes greater than six. This lowering of the threshold allows for more data to be collected in recent years, which greatly improves the resolution of the inverted

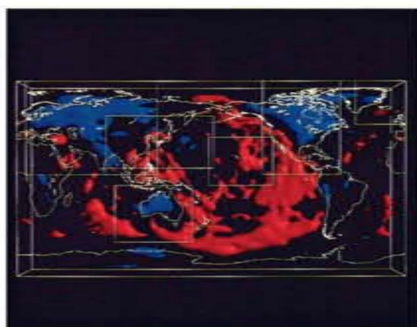


Figure 1. A Mercator projection of the Earth's upper mantle. Each box represents a figure to be explained in the text. Seismic isosurface values: Blue (Cold) 1.87% faster than the global seismic average, Red (Hot) -1.11% slower than the global seismic average.

model. In this study, the Californian seismologists employed surface waves which arrive after the initial compressional (P) and shear (S) waves. Surface waves propagate close to the Earth's surface and do not penetrate into the deep parts of the mantle. Therefore, these images will pertain just to the top 410 km of the Earth's upper mantle. Surface waves are used for tomographic study because of their inherent high signal-to-noise ratio over body waves. As mentioned previously, the resolution of the data improves with the acquisition of larger data sets. Presently, we can resolve upper mantle structure down to 400-500 km in depth. In this depth range, one can find important evidence for understanding mantle dynamics and the connection of mantle flows to surface manifestations of

plate-boundaries and 'hotspots', such as Hawaii.

In the inversion approach used by Tanimoto and Zhang, the average phase velocity is measured between earthquakes and the seismographic stations. In this way one can obtain the deviation of the phase velocity from the global average. This perturbation is related by a mathematical relationship to the S-wave velocity perturbation from the global average. Perturbations in the S-wave speed are caused by local changes in the thermal and chemical fields inside the Earth. One can classify then the perturbation in the phase velocity as an observed datum. The S-wave velocity perturbation as a function of the radius, latitude and longitude is solved for a given data set. The depth resolution is controlled by a function which appears in this integral mathematical relationship and can be computed readily from any given reference Earth model.

The 3D images were retrieved from analyzing about 18,000 surface wave measurements. The number of unknown parameters used to describe the 3D S-wave velocity anomalous structure in the upper mantle is about one thousand. From formal inverse theory, the lateral resolution is determined to be about 1,000 km, and the depth resolution is about 100 km in the 3D images. This rather elongated resolution structure is due to the usage of surface waves, but it must be emphasized that these results still represent a four- to five-fold improvement in the lateral resolution over results published five years ago. Errors for the estimated S-wave perturbations are 0.3-0.4%. As the typical fast and slow velocity variations are 3-4%, the observed velocity variations are clearly statistically significant.

The Data Set

The data set consists of a data point for every two degrees of longitude and latitude and a point every 20 kilometers in the vertical direction down to 650 kilometers. Before final post processing, the data comprise about 2.2 megabytes. The data have been normalized to one byte per data point

to simplify the importing of the data into other visualization programs. The same normalized data were used in IRIS Explorer. The accuracy of the data below about 410 km is questionable. Consequently, all of the figures have been rendered to a depth of 410 km. The total number of data points in the data set to a depth of 410 km is 345,891.

Visualization

The primary technique used in visualizing the Tanamoto/Zhang data set is the isosurface. An isosurface is a surface drawn through a series of common values within a 3D data set. This method has two main advantages; it is unambiguous, and it is quickly drawn in the graphics hardware of the IRIS workstation.

The unambiguous nature of the isosurface is both a boon and a bane. On one hand, it is very easy to interpret. On the other hand, an isosurface can hide the very structure that one is trying to visualize within it. One method used to visualize this missing structure internal to an isosurface is to use surfaces for multiple values. Outer surfaces can be made semitransparent, revealing structure that would be normally hidden (see Figures 4 through 9).

All figures, except Figures 2 and 3, use the Mercator projection that projects a sphere onto a rectangle by drawing the lines of longitude parallel to each other instead of intersecting at the Poles. This can be a very useful method of viewing the entire world at the same time, but the closer the map and data are drawn near the poles, the more horizontally elongated the data become. This can be corrected by using a spherical projection. Figures 2 and 3 show the North Pole and South Pole respectively. Notice the striking difference in the structure of the Antarctic craton between Figures 1 and 3. The vertical direction in all of the Mercator projections is stretched so that each data point in the vertical direction is equidistant to those (two degrees) in the horizontal direction. In the spherical projection of the data set, the depth is not stretched.

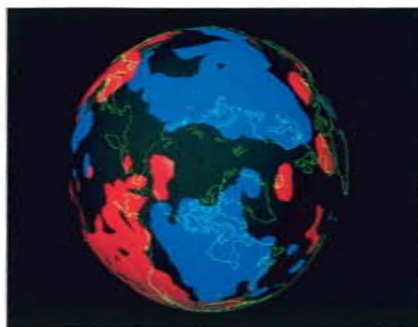


Figure 2. View in spherical geometry of the North polar region. Note the large amount of cold material contained within the North American and Eurasian Cratons. Seismic isosurface values: Blue 1.67%, Red -1.15%.

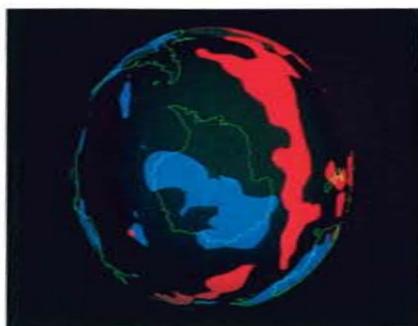


Figure 3. View in spherical geometry of the South Polar Region. Notice the large amount of hot material to the East of Australia. This correlates with a series of underwater ridges in the South Pacific. Seismic isosurface values: Blue 1.06, Red -1.76%.

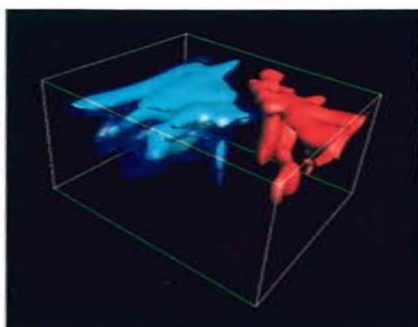


Figure 4. Perspective of North America looking North West toward Alaska. 132° to 60° West Longitude. 4° to 90° North Latitude. The gap between the hot and cold material is directly below the Rocky Mountains. Also notice the cold root protruding beneath the North American craton. This root is discussed in the text. Seismic isosurface values: Blue 1.67, Light Blue 2.52%, Red -1.31%.

The increased productivity resulting from the combination of the Personal IRIS and the POWER Series workstations along with the IRIS Explorer software in interpreting the data cannot be emphasized enough. The graphics hardware in the G, TG and VGX workstations used at the Minnesota Supercomputer Institute and the Army High Performance Computing Research Center made the manipulation of this two-megabyte data set second nature. IRIS Explorer software made prototyping and changes simple and quick. It increased visualization productivity manifold over the volume rendering and contour plot methods previously used. Imputing the data (a common problem with scientific software) was made trivial with an easy-to-use program called DataScribe. Modules for the most important visualization tasks, including making a subset of the data and taking slices of a 3D data set and volume rendering, are included with IRIS Explorer. Most importantly, the network (the way individual modules are connected to each other) can be changed quickly and whenever necessary — so that if a researcher has an idea, it can be implemented immediately without losing the train of thought.

IRIS Explorer also allows various parts of visualization programs to be distributed to other IRIS workstations, and they are soon to be distributed to computers from other manufacturers such as CRAY™ and Connection Machine™. This means that computationally intense sections of a visualization can be distributed to machines with (a) fast CPU(s), while the display and rendering can be performed on a computer which is designed for graphics.

3D Tomographic Images of the Earth's Interior

Depicted are the 3D tomographic images obtained using IRIS Explorer on Silicon Graphics workstations. The Earth's upper mantle to 410 km in depth is shown in Figure 1 in Cartesian format. Each box represents the boundaries of Figures 4 through 9. This global image is produced from surface rendering techniques. The blue areas represent the cold continental cratons of North America to the right, Eurasia to the

left and Australia in the lower left half. The red mass represents hot (slow) material. A very prominent feature is the patch of hot (red) material girdling the Pacific basin, from the American continents to the western Pacific. Australia is surrounded by hot mantle material as well. One can see also that the Hawaiian Islands lie above a rather hot upper mantle.

When the upper mantle is projected as a spherical shell in Earth dimensions, it appears rather flat. This is known as "shallow-water" projection, as the depth of the upper mantle is less than ten percent of the radius of the entire planet. Figures 2 and 3 depict, respectively, such projections over the north and south polar regions. There are clearly more cratonic (blue) areas over the Northern Hemisphere. Note that the upper mantle beneath the South Pole, however, is colder than in the North Pole. One sees in Figure 3 that Antarctica can be divided into different tectonic provinces by the old cratonic (blue) sector in the middle that crosses the South Pole. The northern extent of the craton beneath Greenland is also illustrated in Figure 2.

Illustrating features associated with the dynamics of the Earth's interior in 3D, these images yield far more information within a shorter period of time than if one used traditional 2D graphics.

Figure 4 depicts a 3D image of North America that is divided by its geological history into two parts — the cold, old eastern craton and the younger hot (red) western craton. This geological dichotomy in the tectonics is easily observed from the surface. The deep red root is a hot plume emanating from the mantle through the Gulf of California. Two different isosurfaces have been employed to describe the cold East. The cold detached root (blue slice in the middle) can be observed better with this isosurface scheme. This root falls right under the New Madrid seismic zone at the Tennessee border of Missouri. Historically, there have been numerous large earthquakes in the area above the detached cold root. The Rocky Mountains coincide with the gap separating the cold East from the hot West — a trend that extends well into northern Canada.

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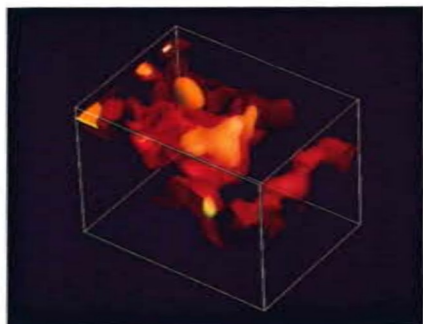


Figure 5. Hawaiian Islands, looking from the south. 178° East to 122° West Longitude. 6° South to 38° North Latitude. Note the lighter colored hot material in the center of the volume. This hot material is the hotspot which created the Hawaiian Islands. Seismic isosurface values: Red -0.95%, Yellow -1.56%.

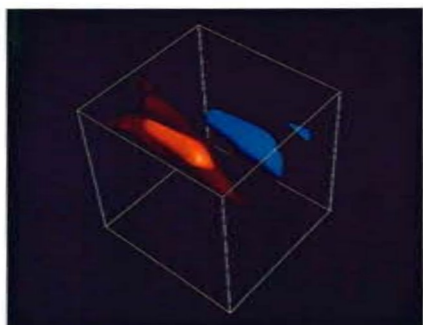


Figure 6. Iceland looking from the southeast. 38° West to 0° Longitude. 42° to 90° North Latitude. Notice the difference in structure compared to Hawaii. The cold (blue) material is a piece of the North American Craton in Greenland. Seismic isosurface values: Blue 1.87%, Red -0.62%, Yellow -1.39%.

The Hawaiian Islands were built from past and ongoing volcanic eruptions. One can understand why so much volcanism has been generated in this region of the Pacific by viewing Figure 5, which shows the hot material with two different isosurfaces. The lighter color material is hotter than the surrounding red. There is no cold material at all beneath Hawaii. The blob-like features may be indicative of the strongly time-dependent nature of flows in the mantle beneath the Hawaiian Islands. In contrast to Hawaii, the upper mantle beneath Iceland is quite different (Figure 6). The blue patches are associated with the cold material of Greenlandic and North American cratonic areas. It is peculiar that the Icelandic upper mantle is not as hot as the Pacific beneath Hawaii.

The Australian craton and its surroundings are shown in Figure 7 — one will note another root on the east coast of Australia. There are earthquakes along the east coast of Australia that may be related to the presence of this cold root, similar to the one beneath Tennessee (Figure 4). The Australian continental plate is surrounded by hot mantle to the east (left). The complexity of the Japanese Islands and eastern Asia are depicted in Figure 8. In the foreground are cold patches representing old oceanic plates (with double isosurfaces). The Japanese Islands are also of volcanic origins — the red sausage-like mass portrays the complexity of the tectonics below the Japanese Islands. The cold (blue) masses in the lower part represent subducting processes beneath Manchuria and northeastern China.

Finally, Figure 9 depicts the Eurasian cratonic (blue) mass with double isosurfacing. The cold root lies beneath the Ukraine. The hot material in the back is associated with the subduction processes in the Indonesian Island region. The red patches in the front come from the Mediterranean and the Red Sea regions. Also, cold material is present in the Himalayan region (middle of the box).

Through these examples, one cannot deny that the interactive graphical usage of 3D

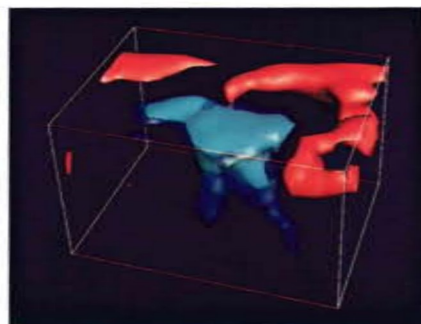


Figure 7. Australia looking toward the south. 90° to 162° East Longitude. 6° to 58° South Latitude. The hot material (blue) is directly below oceanic ridges just south of Australia. Seismic isosurface values: Blue 1.22%, Light Blue 1.79%, Red -1.48%.

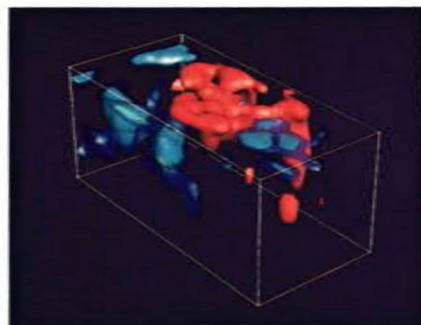


Figure 8. Japanese Islands and eastern China looking southwestward from the Aleutians. 82° to 182° East Longitude. 10° to 58° North Latitude. The cold material in the foreground is called the Shatsky Rise, a piece of cold lithosphere in the North Atlantic. The hot (red) material is directly below Japan. The cold (blue) material in the background is an area beneath Manchuria and Southwestern China which is subducting beneath hotter material. Seismic isosurface values: Blue 1.22%, Light Blue 1.74%, Red -1.11%.

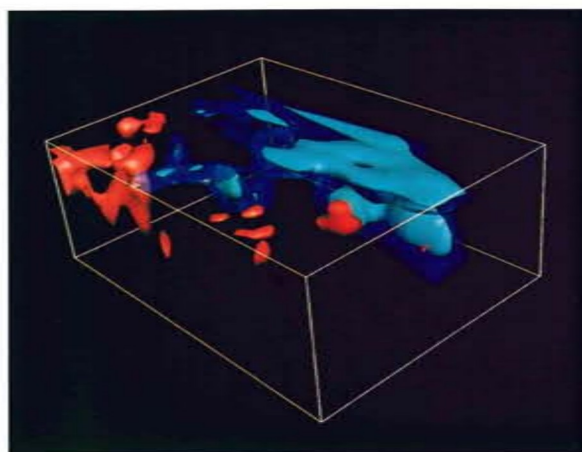


Figure 9. The Eurasian land mass looking northeastward from central Africa, 8° to 130° East Longitude, 4° North to 90° North Latitude. Note the large, cold (blue) cratonic root beneath Ukraine. The front corner of the volume is the location of North and East Africa. Notice that it is completely transparent indicating the African craton is much warmer (and subsequently older) than the Eurasian Craton. Seismic isosurface values: Blue 1.79, Light Blue 2.73, Red -1.48%.

tomographic data will indeed revolutionize the way geoscientists look at the Earth's interior. Illustrating features associated with the dynamics of the Earth's interior in 3D, these images yield far more information within a shorter

The increased productivity resulting from the combination of the Personal IRIS and the POWER Series workstations along with the IRIS Explorer software in interpreting the data cannot be emphasized enough.

period of time than if one used traditional 2D graphics. Knowledge of the dynamics of the Earth's interior is fundamental to our knowledge of the environment from the obvious surface manifestations of earthquakes and volcanic eruptions.

The authors wish to thank Philip van Valkenberg of the Minnesota Supercomputer Center for his invaluable help in producing many of the images appearing in this article.

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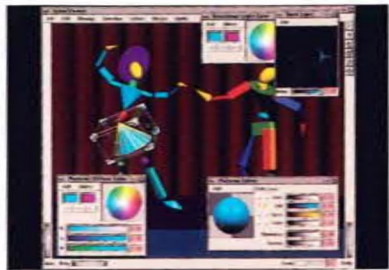
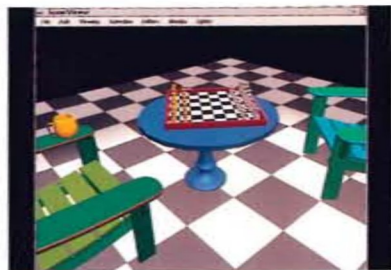


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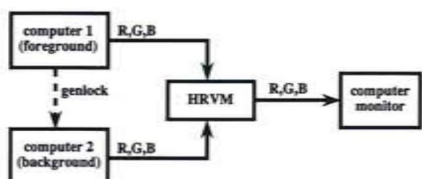
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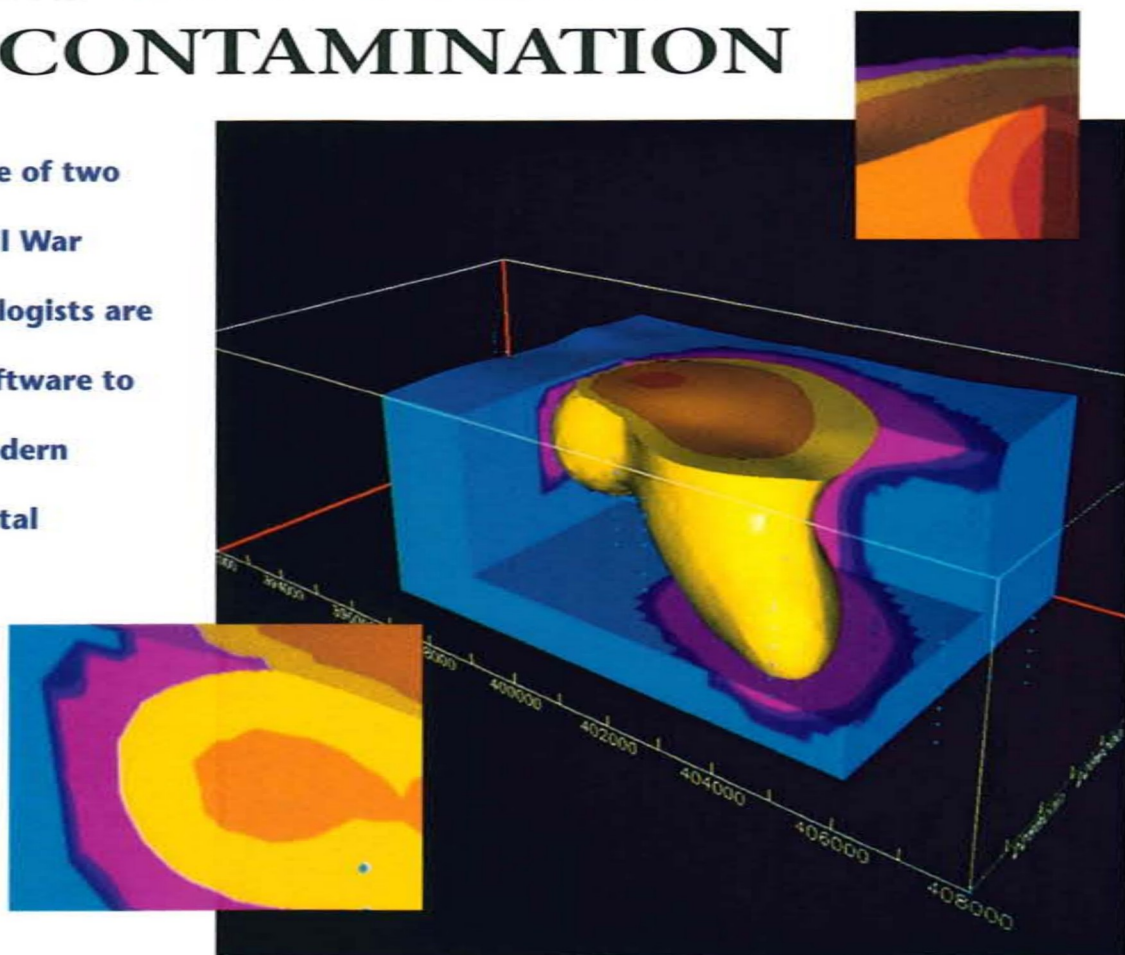
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BATTLING GROUND WATER CONTAMINATION

Near the site of two
decisive Civil War
battles, geologists are
using 3D software to
attack a modern
environmental
adversary.

BY SCOTT
DAILEY



Interactive Volume Modeling (IVM) 3D visualization of the PCE contaminant plume concentration under Manassas, Virginia.

One-hundred-thirty years ago, the sounds of Manassas were defined by the thunder of heavy artillery and the crackle of rifle fire, as Confederate forces twice routed Union troops during the battles of Bull Run in the summers of 1861 and 1862. Today, the fields and woods around Manassas are rapidly giving ground to the unyielding march of suburbanization. For, over the past two decades, northern Virginia has been developed into one of the nation's most desirable living areas.

But under the fast-shrinking farmland, where an estimated 185,000 soldiers clashed, a battle is still raging. In place of the Confederacy's Stonewall Jackson and the Union's Irvin McDowell is a small army of scientists and technicians. Instead of iron artillery and bayoneted, long-barreled rifles, the weapons are worksta-

tions and 3D graphics software. And the battle is no longer over union, or slavery. It is the typically modern struggle of an industrial nation — the continuing fight to clean up chemicals that have seeped into the groundwater and infiltrated a public well near a local manufacturing plant.

The underground chemical "plume" is formed where the solvent tetrachloroethylene (PCE) has dissolved into the groundwater. Like dye seeping through a giant sponge, the PCE has crept through an area one mile in length and up to half a mile across. Investigating geologists believe that, in its deepest penetration, the chemical has quietly permeated as much as a thousand feet downward into the thick, fractured rock that lies beneath the ground.

Worrisome as it might seem, the task of purifying the water is relatively straightforward. Water-quality technicians simply pump the water from the wells through carbon filters, trapping the PCE along the way. Thus cleansed, the water is then released to the local sewer system.

But the battle to clean up the toxic plume has been anything but easy. The efforts have been going on for years. And, as in any warfare, the problem comes down to this fundamental: you can't attack an enemy you can't see.

"Most of geology exists below the surface — it's invisible," says Mark McBride of the Bethesda, Maryland office of Dames & Moore, the environmental consulting firm that has inherited the assignment of assessing the extent of the plume. McBride is a hydrologist — a geologist who specializes in water-related issues. He's also a pioneer in using 3D visualization to study hydrogeological problems such as the chemical plume beneath Manassas.

"In geological work, and in particular, contaminant hydrogeology, we have to deal in three-dimensional relations. When you look at where the chemicals have flowed, you're looking not only at how far they have traveled north, south, east and west. You're also looking at the depth of the penetration and the concentration of the chemical constituent."

In his examination of the Manassas PCE plume, McBride has relied on a 3D visualization package called Interactive Volume Modeling (IVM), produced by Alameda, California-based Dynamic Graphics, Inc. Running on a Silicon Graphics Personal IRIS workstation, Dynamic Graphics' IVM arranges geologic data into colorful, 3D renderings that display the length, width, depth and makeup of surface and underground phenomena. In essence, IVM gives geologists the "X-ray vision" needed to see beneath the surface of the earth.

"There are many types of data that are needed for site investigations," explains Glenn Morris of Dynamic Graphics' east

Interactive Volume Modeling

The development of Dynamic Graphics' Interactive Volume Modeling (IVM) pretty much parallels the continuing story of 3D visual processing.

"It was becoming very clear to us that we had 3D problems and 3D data sets, but we only had 2D tools," says Dennis Smith, Dynamic Graphics' director of environmental marketing. At the time — the mid-1980s — Smith was working with computer graphics at Woodward-Clyde Consultants, a Northern California environmental analysis firm. He was using IVM's predecessor, a 2D product called Interactive Surface Modeling (ISM), a package employed extensively in Dynamic Graphics' primary market, the oil and gas industry.

Mindful of environmental professionals such as Smith, Dynamic Graphics began creating the three-dimensional IVM package. Increasingly intrigued, Smith joined the company a couple of years later, while IVM was still being developed.

Since introducing IVM three years ago, privately held Dynamic Graphics has sold the package to such diverse clients as Esso Canada, Lawrence Livermore National Laboratory, the U.S. Army Corps of Engineers, the U.S. Air Force, the U.S. Office of Surface Mining Reclamation and Enforcement and consulting firms such as Dames & Moore and Environmental Science & Engineering, Inc. (ES&E). "A primary appeal," says Dynamic Graphics' Glenn Morris, "is its potential for shortening the regulatory process, which can translate into significant savings for organizations that must submit their operations or plans to environmental review."

"The longer the EPA takes to make a decision, the longer the project is going to take and the more it's going to cost. The regulators are so busy and overworked, that for them to get all of the necessary information is very com-

plex and very difficult. IVM can help the client put the entire package together, with all of the necessary data, in a way that makes it highly comprehensible to the regulator."

Dynamic Graphics approaches the environmental market from three angles. In one corner are organizations ranging from manufacturers to the U.S. Department of Energy, whose work can involve environmental issues. Dynamic Graphics' marketing staff calls such customers "potentially responsible parties", because they are the ones who may be required to fix environmental problems should they occur.

In the second corner are the regulatory bodies, such as the U.S. Environmental Protection Agency, state and local regulatory agencies and the U.S. Office of Surface Mining. The triangle is completed by the organizations that do much of the analysis for the other two — environmental consulting firms. "IVM's market," says Morris, "is tied to the need of the three groups to work closely together."

"The regulatory agency sets the standards. The consulting firms send their reports either to the agency or the potentially responsible party — whichever they're working for, and, generally consultants tend to work for one or the other. And the potentially responsible party has to have the information and be able to work with it in order to comply with the agency's requirements."

After assessing the market, Dynamic Graphics found its first wedge in the consulting field, with customers such as Dames & Moore, ES&E and others willing to invest in better information and higher productivity. "Slowly, what's happening is that the market dynamic is starting to take over," Morris says. "Now that some of the firms have the product, they're starting to raise the competitive fervor of the others."

coast office, also in Bethesda. "Generally, they all fall into two categories — 2D and 3D. The 2D information consists of things such as surface topography, site maps, historical aerial photos and lithology horizons — the levels where groundwater begins, where bedrock begins, for example.

The 3D information involves things like resistivity, permeability, porosity and contaminant concentrations.

"What IVM does is put all this 2D and 3D information together, to create an integrated view of the site with all of the data.

Then the scientist can interactively analyze the site. You can also interface the data with the important components, such as predictive groundwater models and time-series animations — a rapid-fire series of ‘snapshots’ that might show, for example, the spread of a chemical through the soil over time.”

To begin investigating an underground chemical plume such as the one around Manassas, geologists drill a pattern of test wells, and then sample the water or soil taken at each site. Traditionally, the locations and concentrations of chemicals found at the test wells are then plotted as data points on two-dimensional cross sections and maps.

That’s good as far as it goes. But, as McBride proved in his study of the Manassas plume, it’s often not far enough.

“Dames & Moore took over at a site where other consultants had been working,” McBride recalls. “There were more than forty test wells there already. We looked at the previous data, and found that the plume was probably heading northward, away from the probable source. There was one well, toward the north, that had a low concentration of PCE. Looking at the situation two-dimensionally, you might conclude that this well marked the end of the plume. But because of the northerly flow, we believed the plume probably extended farther. If you looked at it in the third dimension — the vertical dimension — you realized that the well might be too shallow. We drilled another three-hundred feet down, and we found a much higher concentration of PCE. Given that information, we continued to drill farther to the north, and found that the plume extended pretty much as we had inferred. If we had neglected that third dimension, we could have been totally off in our calculations.”

Another reward, says McBride, has been a dramatic increase in productivity. “One obvious advantage is in the interpretation of data. IVM is a whole lot faster than the conventional methods of hand-drawing

cross sections and maps. It took us about eight hours to create three-dimensional renderings with IVM, as opposed to about two weeks that would have been required for two-dimensional cross sections using conventional methods. That probably brings us out ahead, even considering equipment costs.”

Beyond the gain in productivity, McBride also believes IVM provides a more complete and accurate view than traditional drafting.

“Often, we’re constrained in where we can put our wells and borings,” he says. “At industrial sites, in particular, there may be buildings or parking lots or other obstructions, so we can’t always put the wells in neat lines. When you draw the cross section, inevitably there are lots of wells that don’t fit onto the sections. You have to throw those data out, and then extrapolate and interpolate from the other data. And the accuracy of the interpolation is always fairly questionable.”

“That problem doesn’t occur with IVM, because it does more accurate three-dimensional interpolations than we can generally do in two dimensions. The things you’re interested in will be very rigorously interpolated. It’s probably a lot more accurate representation of what’s going on in the subsurface than if you based the data only on the wells that fit in the cross sections. That not only provides a higher level of accuracy,” says McBride, “it also creates a vivid illustration that helps in communicating scientific findings to clients and the public. That is something that could provide an advantage to Dames & Moore in the highly competitive field of environmental consulting.”

“My basic reaction was, ‘Gee, what a neat image.’ It’s very impressive. Our experience has been that it goes over very well with clients. On one job, the client is insisting that we use IVM in all of our future presentations. I definitely feel it will give us some advantage. Right now, I’m itching for an opportunity to use IVM in a big public presentation.”

That opportunity may come as further study and cleanup efforts continue around Manassas. Because PCE is easily captured by activated carbon filters, separating it from the groundwater supply has been fairly simple. But the constant filtration treatments will have to go on until the site has been cleansed of hazardous levels of PCE. “And, that,” says McBride, “is the real challenge.”

“Halogenated solvents such as PCE tend to sink very rapidly into the ground, where they tend to form little blobs that will sit there and dissolve over time. The pumping system gets rid of the high concentrations of PCE in the water, and it will continue operating until the problem no longer exists. But a lot of the blobs of solvent can get trapped in fractures and ‘blind pores’ — little dead-end openings in rock and among sand grains. They dissolve slowly, because they are partially protected from the groundwater, which would otherwise flush them away. The result is that it can be a slow process to remove the solvent from these dead-end openings.”

“The physics of this sort of chemical transport is not well-understood,” McBride says. On the positive side, he says that IVM provides “a natural tool for investigations of these blobs.”

So, one-hundred-thirty years after the first two battles, the third battle goes on. In perhaps a fitting historical footnote, the Union’s commanding general at Bull Run was John Pope, an engineer who experimented with artesian wells. On September 1, 1862, Pope was defeated and his troops withdrew to Washington. But equipped with their 3D software and techniques of visual processing, McBride and his brigade of fellow geologists have the adversary in their sights, and expect to prevail ultimately.

Scott Dailey is a San Francisco Bay Area freelance writer.

Joyce Connelley, another Bay Area freelancer, contributed to the historical research for this article.

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Article 3.

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The Fifth IEEE Symposium on Computer-Based Medical Systems will take place June 14-17, 1992 at Duke University in Durham, North Carolina. The symposium targets engineers and computer scientists who are designing and developing computer-based medical systems. The program includes presentation of technical papers, posters, panels, tutorials, software demonstrations and research laboratory tours. The symposium organizers also encourage reports about applications in progress.

For more information, contact: Pete Santiago, Dept. of Radiology, Bowman Gray School of Medicine, Medical Center Blvd., Winston-Salem, NC 27157, phone (919) 748-4260, fax (919) 748-2870, or email: cbms@mrips.bgsu.wfu.edu.

Singapore Welcomes ICARV 92

The Second International Conference on Automation, Robotics and Computer Vision (ICARV 92) will be **September 15-18, 1992** in Singapore. The theme is "A Glimpse of the 21st Century" in the context of intelligent industrial automation. The conference will include theory, applications, plenary and tutorial sessions and an exhibition. Nanyang Technological University, and the Institution of Engineers, Singapore, jointly organized ICARV 92 in cooperation with the IEEE Computer Society, IEEE SMC Society and IEEE Singapore Chapter.

Papers describing original theoretical and/or applied work in, though not limited to, the following areas are invited: robotics, computer vision, AI and expert systems, real-time systems, intelligent automation, neural networks, control applications and motion control. Four copies of an extended summary of three- to five-hundred words are due by April 30, 1992 to the address listed below. If accepted, final manuscripts would be due June 30, 1992.

For more information, contact: ICARV 92 Secretariat, Associated Conventions and Exhibitions, 204 Budit Timah Road, #04-00, Boon Liew Building, Singapore 0922, phone (65) 732-6839, fax (65) 732-6309 or email: emital@ntvax.bitnet.

Symposium on Interactive 3D Graphics

The 1992 Symposium on Interactive 3D Graphics will be held **March 29-April 1, 1992** in Cambridge, Massachusetts. The focus of the symposium is the topic: "What is today's frontier in real-time, interactive 3D graphics?" The symposium will consist of technical sessions in which formal papers are presented and discussed. There will also be hands-on demonstrations by research groups and equipment vendors. The technical presentations at the symposium will focus on innovative 3D graphics and display architectures and hardware, algorithms for generating visual, haptic and auditory output, perceptual and psychological issues of viewing and operating in complex virtual spaces, real-time dynamics, innovative human-machine interface paradigms and interactive simulations distributed over local and long-haul networks.

The 1992 Symposium on Interactive 3D Graphics is organized in cooperation with ACM SIGGRAPH. Attendance will be limited to 125 participants. The registration fee is \$250, which includes the proceedings, reception, banquet and two lunches.

For registration information, contact: MIT Conference Services Office, Room 7-111, 77 Massachusetts Avenue, Cambridge, MA 02139 or call (617) 253-1700.

Balancing CHI '92

This year SIGCHI is celebrating the tenth anniversary of the organized study of HCI (Human-Computer Interaction), begun at the Gaithersburg Conference on Human Factors in Computing Systems in 1982. The theme of CHI '92, *Striking a Balance*, is a celebration of the diversity of the HCI community and a recognition of the human need to find a balance among research, product development and education, among the various domains that contribute to HCI, and among the differing perspectives of science, engineering and art.

The goal for CHI '92 is to provide participants with an opportunity to explore all the facets of HCI. The CHI '92 program features papers, panels, posters and laboratory overviews covering a broad spectrum of HCI activities. The program is expanded this year, giving strong attention to both research results and the practical experiences of people putting HCI research to work. Through demonstrations, videos, exhibits and the Interactive Experience, participants will make direct contact with key products, prototypes and people in this field. Participants are encouraged to select from a wide range of tutorials, workshops and special interest groups to match their interests and needs. Come to Monterey May 3-7, 1992 to help SIGCHI take human-computer interaction into its second decade.

For more information, contact: Caroline Young, CHI '92 Registration, 996 Del Norte Dr., Livermore, CA 94550, (510) 294-9489 or fax (510) 422-5977.

Prix Ars Electronica

Prix Ars Electronica provides the Ars Electronica Festival, which is organized by the Brucknerhaus Linz and the Upper Austrian Regional Studios of the Austrian Broadcasting Company (ORF) cooperatively, with an ongoing forum for competition for computer artists. The Ars Electronica Festival places a topic from the interweaving area of Art-Technology-Society in the forefront every year. The Prix Ars Electronica is able to present an overview of the ongoing development in the area of computer art on the basis of the results of this competition and their documentation for the last five years.

The prize for the competition, which will include four categories in 1992 (Animation, Graphics, Music, Interactive Art), is donated by the VOEST-ALPINE STAHL AG, bSiemens Kulturprogramm and Siemens AG Österreich. The Ars Electronica will take place June 23-27, 1992 in Linz, Austria. The Prix Ars Electronica prizewinners will be presented, with their works, at the Ars Electronica '92 in Linz. This year's theme will be "The World from Within — From Endo to Nano". This topic will be featured in exhibitions, film and media presentations, performances and symposia.

For more information, contact: Rachel Carpenter, Prix Ars Electronica, 82 Queva Vista, Novato, CA 94947 USA, (415) 892-8254.

Barcelona was Not Built in a Day

Digital Pictures of London, England has completed modeling and animating the city of Barcelona for a forty-five second commercial. The project was commissioned by Port 2000 through Division Video in Spain to illustrate the transformation of the Barcelona port areas. Their previous work for the DTI British Pavilion in Seville and the Hong King airport proposal made Digital Pictures an obvious choice for a project of this size and detail.

Before the project started, a producer and a chief animator visited Barcelona to take reference photos and plan camera shots for both live action and computer animation. Back in London, project director Kim Aldis used street plans and building designs to design the eight second live action tour of the present day Barcelona port. The scene then cuts to thirty-two seconds of computer animation that reveals the changes that will be taking place in the port. The database for this animation was created by a team of animators who digitized models of existing buildings based on an architect's plans. The city digitized, the next step was to make it appear to grow or build. This was achieved using animated texture maps, fading up from transparent to fully opaque buildings. The marina and port water expanses were created using bump maps. Cloud shadows were passed over the water's surface adding to the effect.

The end result is a fast moving camera flight over Barcelona, its new buildings and piazzas forming as one flies over. The whole process took four animators four weeks to complete using Digital Pictures Digipix software running on Silicon Graphics 4D/20s. The live action was combined with the animation on a Harry at the Molinare post production facility.

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My industry is:

- | | | |
|---|---|--|
| ☐ Creative Graphics | ☐ Government | ☐ Research |
| ☐ Arts | ☐ Dept. of Defense | ☐ Chemistry |
| ☐ Entertainment | ☐ Dept. of Energy | ☐ Geosciences |
| ☐ Lithography | ☐ Dept. of Trans. | ☐ Medicine |
| ☐ Manufacturing | ☐ Health | ☐ Pharmaceutical |
| ☐ Aerospace | ☐ NASA | ☐ Other Life Sciences |
| ☐ Automotive | ☐ Other | ☐ Computer Software Dev. |
| ☐ Computing | ☐ Building/Construction | ☐ Education |
| ☐ Petroleum | ☐ Architecture | ☐ Other _____ |
| ☐ Textiles | ☐ Engineering | |
| ☐ Other | | |

My application interests are:

- | | |
|--|---|
| ☐ Animation | ☐ Mechanical CAD/CAM |
| ☐ Architectural Design | ☐ Mission Planning |
| ☐ Artificial Intelligence | ☐ Molecular Modeling |
| ☐ CAE | ☐ Pre-press |
| ☐ Finite Element Analysis | ☐ Visual Simulation |
| ☐ Fluid Dynamics | ☐ Robotics |
| ☐ Image Processing | ☐ Scientific Visualization |
| ☐ Industrial Design | ☐ Other (Specify) _____ |
| ☐ Man/Machine Interface | |

My IRIS workstation is a:

- | | | |
|---------------------------------------|---|--|
| ☐ Power Series | ☐ 4D/G | ☐ Personal IRIS |
| ☐ 4D/GT | ☐ 1000/2000/3000 | ☐ IRIS Indigo |

The number of IRIS workstations at my site is:

- | | | |
|-------------------------------|--------------------------------|---------------------------------------|
| ☐ 1-5 | ☐ 11-20 | ☐ More than 50 |
| ☐ 6-10 | ☐ 21-50 | ☐ None |

Software Utilized:

- | | |
|---|---|
| ☐ Public Domain Software
(please specify) _____ | ☐ Custom Software |
| | ☐ Third-Party Software |

My job function is:

- | | | |
|---|--|---|
| ☐ Corporate Mgt. | ☐ Engineering Mgt. | ☐ Research Staff |
| ☐ Marketing | ☐ Engineering Staff | ☐ Other _____ |
| ☐ Consulting | ☐ Creative Staff | |

My organization's total sales volume or budget:

- | | | |
|--|--|--|
| ☐ Less than \$100,000 | ☐ \$101,000-\$1 Billion | ☐ More than \$1 Billion |
|--|--|--|

Number of employees at my company:

- | | | |
|------------------------------------|-----------------------------------|---------------------------------------|
| ☐ Under 250 | ☐ 251-5000 | ☐ 5000 or more |
|------------------------------------|-----------------------------------|---------------------------------------|

I purchase or influence the purchase of the following graphics and imaging products:

- | | |
|---|---|
| ☐ PCs | ☐ Storage or memory devices |
| ☐ Workstations | ☐ Color Printers |
| ☐ Supercomputers | ☐ Laser Printers |
| ☐ Networking products | ☐ Hardcopy supplies |
| ☐ Boards/controllers/subsystems | ☐ Presentation systems |
| ☐ Monitors/Displays | ☐ Tablets, digitizers, spaceballs or other input devices |
| ☐ Scanning/image capture devices | |
| ☐ Plotters | |

Do you use or own an SGI workstation? ☐ Yes ☐ No

If so, what is the serial number? _____

What can Silicon Graphics teach you?

Please send me information on the following courses:

Name: _____

Title: _____

Company: _____

Address: _____

Phone: _____

- | |
|--|
| ☐ Graphics Programming I |
| ☐ Graphics Programming II |
| ☐ PowerVision Graphics |
| ☐ Parallel Programming |

- | |
|--|
| ☐ Mastering IRIX |
| ☐ System Administration |
| ☐ Network Fundamentals |

- | |
|---|
| ☐ Self-paced Personal IRIS Maintenance |
| ☐ System Maintenance |
| ☐ Multi-processor Maintenance |

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EarthStation Multimedia Suite

The amount of information available about the state of planet Earth, with all of its subsystems, continues to increase dramatically. This flood of data comes from direct satellite observations, more traditional methods such as ground based observations and computer simulations. The representation and structuring of this rapidly changing information was addressed by the EarthStation installation. EarthStation used modern communication, computers and interactive multimedia technology to communicate its information. EarthStation is a computer based, multimedia approach to a global information and simulation environment that was presented at Ars Electronica '91 in Linz, Austria.

The theme of the yearly Ars Electronica Festival highlights the interrelationships of art, technology and society. The 1991 theme "Out of Control" asked the fundamental question, "Does technological development have only positive aspects?" According to Gottfried Mayer-Kress, coordinator of the multinational installation, "Our main interest was to demonstrate the power of modern computational tools with respect to adaptability and interactivity. We constantly updated the global environmental models, and included some issues of current affairs that seemed strongly coupled to global dynamics."

The EarthStation installation consists of two major connected parts: Part 1, the interactive, graphic representation of the state of the earth; and Part 2, the simulation and visualization of nonlinear dynamic models of global systems. The first part shows how modern communication and computer technology can help us

to obtain an image of our complex world with an accuracy and detail that was unimaginable only a few years ago. The second part suggests how we can approach the concept of an EarthStation from a reconstructive perspective using the artificial reality of computer simulations.

The basic framework of Part 1 of this installation consists of a virtual reality interface called fractal boxes. This interface is designed for the interactive exploration of the complex relationships between different data bases. This application was developed by Gideon May, with graphic design by Jenifer Bacon and audio by Gregory Kramer. The virtual world is reached through an entrance hall that contains a suspended globe, a map of the earth on the far wall, text on the left wall and a schematic representation of the network on the opposite wall. When one enters the globe, each problem area of the global environment is presented as an object in virtual space. These objects are 3D nested fractal boxes. Each box is labeled on the outside with the name of a problem area, graphics and photo images. Inside the box, there are more text, photos and diagrams pertaining to the problem areas. Each box also contains its own characteristic sound environment.

One can continue to enter boxes within boxes, following a particular issue until the complexity level of the issue's data base is exhausted. Some of the objects/data bases that can be accessed through the fractal boxes interface include computer images from NASA/NOAA satellites and geographic information systems on population, economics, politics, military data and Earthwatch. The geographic displays use various software packages including Brad

de Graf's "Electric Atlas" for statistical analysis and correlations of atmospheric data when based on satellite data, and Silicon Graphics' VDL for data base visualization.

Part 2, the representation, simulation and visualization of nonlinear dynamical models of global systems, is demonstrated by PhaseSpaceShip. It presents different types of simulation tools developed to create an artificial environment to study various aspects of the global system. The dynamics and sensitivity of multidimensional models, specifically a nine-dimensional model for the El Niño phenomenon, were represented on two platforms: the Personal IRIS 4D/35 TG with digitized audio "sound bites", a special sound board from Gregory Kramer's company Clarity, and a speaker-system-provided audio. The simulation of the model and the graphics rendering of the solutions of the model are performed on a IRIS 4D/320VGX with a multiprocessor. An Ethernet network was used to communicate between the two IRISes.

By choosing a radio button, the user selects the projection and perspective of a laboratory "Tower" perspective or co-moving "Cockpit" perspective. A spaceball interface allows the interactive perturbation of the equations of the model. All nine dimensions of the model are represented by a set of maximally orthogonal musical dimensions. This installation explores the possibilities of a new multimedia approach to complex data analysis and representation.

For more information, contact: Gottfried Mayer-Kress, University of Illinois at Urbana-Champaign, (217) 244-5877 or email: gmk@pegasos.santafe.edu.

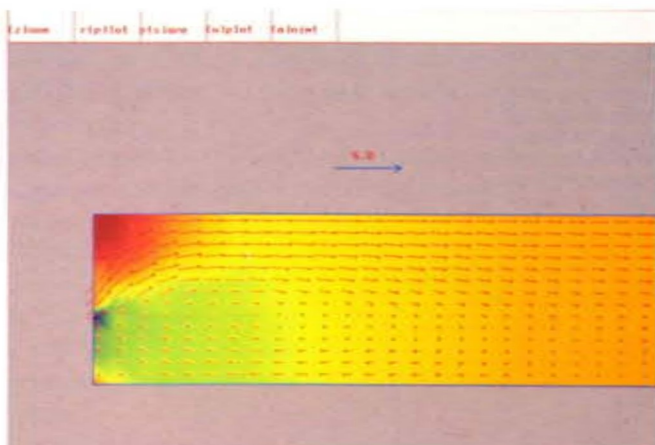
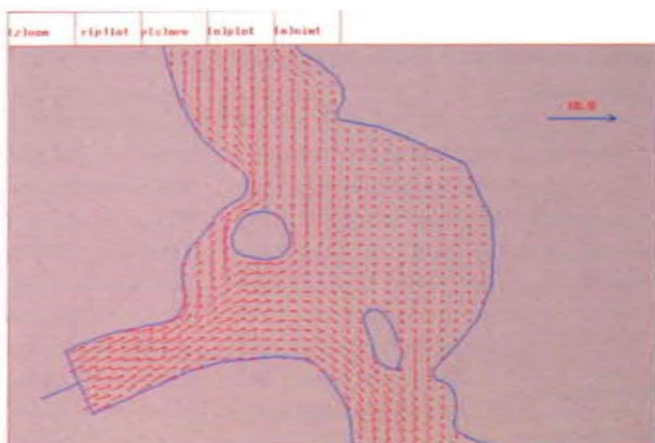
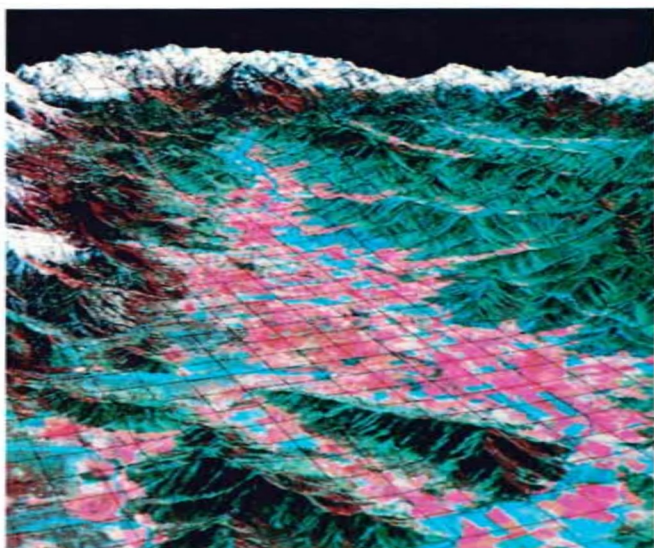
UC Davis Goes Digital

The Environmental Systems Modeling Group (ESMD) at UC Davis is seeking to develop innovative techniques to enhance the capabilities of decision makers. Decision makers need tools to assess the impacts of structural, institutional or operational alternatives that alter the quality of the aquatic environment. These tools include mathematical models to simulate the behavior of aquatic systems, databases and information managers to assemble and organize data needed for modeling. Interactive computer graphics packages seem key to facilitating interpretation of results.

At this point, ESMD's graphics development is directed toward improving the efficiency of their research. However, as they gain more experience with the IRIS, they are focussing their development of Decision Support Systems (DSS) on the Silicon Graphics platform. While research oriented pre and postprocessing graphics are intended to convey precise and often subtle technical information related to the modeling exercise, DDS graphics are intended to convey the essential qualitative and quantitative modeling results in a manner accessible to "non-modelers." Producing such images often requires a more developed visual display as well as a greater level of interaction than is required for research related work.

ESMD's work with the IRISes centers around supporting hydrodynamic and water quality modeling through preprocessing input data and postprocessing model output. Visualization of both model input and output is becoming increasingly important as they take on increasingly complex systems. For example, they have created a 3D view of the Scott Valley in California. Seen from the northwest, the image was created by draping a composite Landsat TM image over a digital terrain model. TM bands 4, 3 and 2 were used to create the composite rgb image. The black grid lines are at a one kilometer spacing, indicating the scale. The graphics capabilities of their Personal IRIS 4D/35 allow a level of interactive editing and output analysis far beyond their previous capabilities.

For more information, contact: John DeGeorge, University of California at Davis, Dept. of Civil Engineering, (916) 752-6697.



The EPA Gets Visual

The U.S. EPA Scientific Visualization Laboratory in Research Triangle Park, North Carolina has created scientific visualizations for researchers within the EPA, and has collaborated on jointly sponsored visualization projects with researchers outside of the Agency. The majority of the Lab's work focuses on the areas of atmospheric research, computational chemistry and fluid dynamics.

The Scientific Visualization Lab has worked closely with the Atmospheric Research and Exposure Assessment Lab (AREAL) at Research Triangle Park (RTP), North Carolina. Using the Regional Oxidant Model (ROM), which predicts ozone levels for the northeastern United States, the Scientific Visualization Lab created animations of fluctuating ozone levels over fifteen-day periods. Similarly, the Lab utilized the Regional Acid Deposition Model (RADM), capable of estimating acid depositions, over the eastern United States to visualize hydrogen peroxide and rainfall.

In its collaboration with NASA/Langley, the Lab used the Total Ozone Mapping Spectrometer (TOMS) data, collected by satellite, to depict and animate changes in global ozone concentrations.

There are two primary software packages currently used by the Lab. One is RRVP, which stands for the ROM/RADM Visualization Prototype. RRVP was originally created to support data from the Atmospheric Research and Exposure Assessment Laboratory's Regional Oxidant Model (ROM) and Regional Acid Deposition Model (RADM). They have also moved other generic gridded data sets into RRVP to create images and animations. The second software package is entitled FAST, which stands for Flow Analysis Software Toolkit. FAST was developed at NASA Ames Research Center for Computational Fluid Dynamics research. At Research Triangle Park, they have also moved ROM, RADM and computational chemistry data into FAST for various scientific visualizations.

Supercomputing Japan '92

This international conference and exhibition will be held April 15-17, 1992 at Tokyo's Sunshine City Convention Center. Organized by the Meridian Pacific Group, it will examine advances in high-performance applications. There will be exhibitions by users, vendors and others in the high-performance computing community.

For more information, contact: Meridian Pacific Group, 116 East Blithedale Ave., Suite 2, Mill Valley, CA 94941, (800) 879-4454, (415) 381-2255 or fax (415) 381-1451.





ARRIScape for Better Backgrounds

Sigma Design introduces ARRIScape software, a new visualization product for enhancing the realism of architectural and landscape renderings. ARRIScape runs on a wide variety of personal computers and UNIX workstations including the Personal IRIS and IRIS Indigo. It provides a way for ARRIS users to create 3D images with great control and flexibility, working through "point-and-click" interface. Unlike hand-drawn renderings, ARRIScape gives users the power to create views from any perspective with just a few clicks of the mouse. Renderings can be captured in a variety of presentation media, both electronic and hardcopy.

ARRIScape is three products in one: a library of realistic 3D objects, a series of color and view manipulation tools and a sky simulation tool for placing realistic "sky backdrops." The product provides more than one-hundred-fifty 3D objects that can be placed in an ARRIS model. These range from palm trees, flowering bushes and American flags to furniture, light fixtures and paintings. To eliminate black backgrounds and add naturalism to computer-generated renderings, ARRIScape provides a sky simulation feature that enables users to create realistic sky backdrops behind shaded models. These backdrops can then be mapped to various blue or sunset hues for dramatic visual effects.

For more information, contact: Michael Godley, Sigma Design, Inc., 1 Van de Graaff Drive, Burlington, MA 01803, (617) 270-1000.

TekBase 3.0 Handles Large Data

Leading Technology Inc. is releasing Version 3.0 of TekBase, a technical data management system. TekBase is designed for scientists and engineers who work with large amounts of technical data. Unlike other databases, TekBase has features specifically designed to handle technical data. The product streamlines data management tasks so scientists and engineers can turn large data sets into valuable information quickly and easily. It is used for applications in industries including aerospace, automotive, telecommunications and semiconductor manufacturing.

The new release includes an X11-based graphical front-end, known as kingfisher, which tightly integrates the functions of data management, analysis and visualization with a point-and-click, drag-and-drop interface. Also included in the release is TSL, a 4GL tool that allows users to create sophisticated applications with interfaces based on Motif or Open Look. Users can move from one interface to the other with no modification to their code.

For more information, contact: Roger McPeck, Leading Technology Inc., 6 New England Executive Park, Suite 400, Burlington, MA 01803, (617) 229-8686 or fax (617) 272-3706.

Software Links PCs with UNIX

UniPress Software Inc. releases a set of DOS-UNIX-Macintosh connectivity software. Included in the set are programs to run and display X Window programs on DOS computers. These products offer personal computer users the means to display, access and run remote UNIX resources from their PC desktops. The connectivity products include: PC-Xview, PC-Connect, XVision and PC/TCP for DOS-based personal computers, as well as eXodus for Apple Macintoshes.

PC-Xview, an X Window server for PCs, turns a DOS-based PC into an X terminal. It is a means of displaying X programs on the

PC, while accessing the power of multi-user UNIX systems. Users can "hot key" from UNIX windows to return to the DOS prompt while UNIX applications run in the background. PC-Connect gives users a Microsoft Windows-based desktop, showing icons from both local DOS and remote UNIX programs. Users can point-and-click to select programs, run them simultaneously in different windows and clipboard cut-and-paste and transfer files between UNIX and DOS. PC-Connect's companion product, XVision, gives MS Windows users the ability to run UNIX X Windows programs on their PCs.

For Apple Macintosh users, eXodus taps

the Macintosh into the X Window Systems available on UNIX computers. X applications run within a Macintosh window with other Mac programs running beside them. eXodus interfaces with UNIX in typical Macintosh style, providing cut-and-paste transfer between systems. To put PCs or Macs on a network, LAN software is required. UniPress offers PC/TCP, a complete network software package to connect PCs onto a network with other PCs or hosts.

For more information, contact: Maureen Russell, UniPress Software, 2025 Lincoln Hwy., Edison NJ 08817, (908) 287-2100 or fax (908) 287-4929.



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Ascension Technology Corporation's newest measurement device, A Flock of Birds, is a fast six degrees-of-freedom tracker. The product measures simultaneously the position and orientation in free space of up to six tiny receivers. Each of its receiver measurements is updated one-hundred times per second. Measurements are referenced to one or more transmitters, emitting a pulsed DC magnetic field. These features make it an ideal interface for virtual reality products.

In virtual reality applications, the visual scene presented to the user is correlated to natural head and hand movements. It is critical to be able to measure such motions and transfer outputs to a host computer without introducing a dynamic lag in the graphics presentation. Tracker lag is defined as the amount of time from the start of a receiver motion until the time the user receives the last byte of information measuring the movement correctly. The Flock has been designed to minimize this lag.

The Flock's new features are also of particular importance in dynamic biomechanical analysis, 3D visualization, interactive entertainment systems, flight simulation and real-time animation.

For more information, contact: Jack Scully, Ascension Technology Corp., P.O. Box 527, Burlington, VT, (802) 655-7879 or fax (802) 655-5904.

AutoCAD — World's Most Popular CAD Package — Shipping on the IRIS

AutoCAD R11 for Silicon Graphics IRIS workstations was introduced at the National Design Engineering Show in Chicago this past February. Later that month it began shipping in the United States. Widely used in the mechanical, architectural, and GIS markets on PCs and workstations, AutoCAD is the world's most popular CAD software with over half a million users worldwide.

Many Silicon Graphics users use AutoCAD to create geometry for their CFD or CAE analysis and have had to keep PCs next to their IRIS workstations for this purpose. With the release of AutoCAD on the IRIS, users now can do their modelling right on the IRIS. AutoCAD is priced the same on all supported platforms and requires IRIX 4.0.1. AutoCAD for IRIS will be available through value added dealers worldwide. Autodesk's new solids modelling package, AME, is also available on the IRIS.

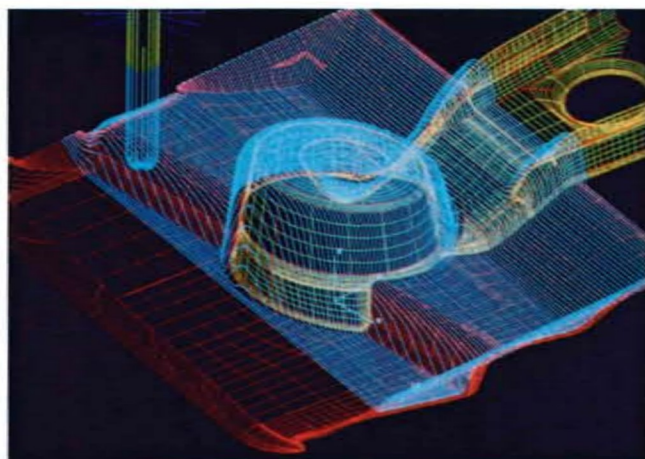
For Silicon Graphics AutoCAD dealers in the United States, call SGI Express, 1-800-800-4SGI and ask for Dave at the Dealer Desk. Abroad, call your local Silicon Graphics sales office.

CAMAX Launches ULTRACAM

CAMAX Systems, Inc. a provider of high performance Computer-Aided Design and Manufacturing software, announces the expansion of its product line with the release of the ULTRACAM software system. ULTRACAM delivers capabilities and performance found previously only in expensive advanced high-performance CAD/CAM systems. CAMAX offers a growth path for existing users of micro-based CAD/CAM software who are seeking a new system with more powerful capabilities.

CAMAX created ULTRACAM by re-engineering and repackaging its flagship product, CAMAND, which is known for its ability to handle the design and manufacturing of complex-shaped mechanical components usually found in automotive, aerospace, industrial and consumer products. ULTRACAM is designed to be easy to learn and use without loss of its powerful capabilities. CAMAX developers replaced many of CAMAND's advanced features with similar capabilities that perform functions better suited to less complicated problems. New features were added, such as ULTRA* CUT, a fast multisurface toolpath generation software module. ULTRACAM and CAMAND are fully compatible and operate on UNIX workstations. Customers can implement ULTRACAM and later upgrade to CAMAND without changing hardware. CAMAX provides a software trade-in credit for customers who upgrade.

For information, contact: Lee Stagni, CAMAX Systems, Inc., 7851 Metro Parkway, Minneapolis, MN 55425, (612) 584-5300 or fax (612) 854-6644.

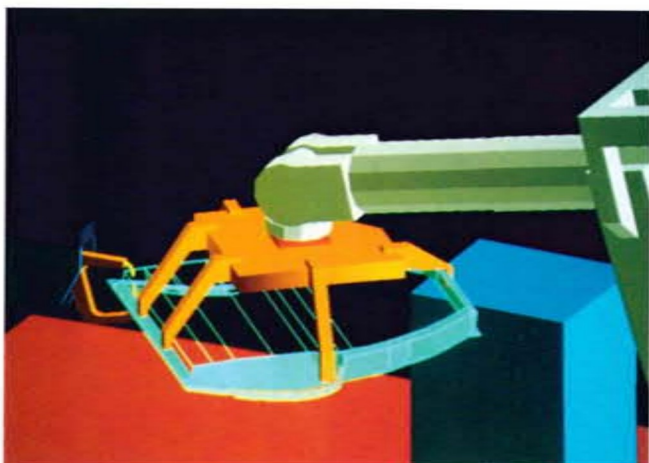


Hardware Interface for Rewritable Optical Drives

Ten X Technology, Inc. announces the OCU-125S, a hardware interface for rewritable optical drives. The OCU-125S is an intelligent hardware interface that solves connectivity problems between operating systems and rewritable optical drives. Common integration obstacles include variations in block size or the lack of removable media support. Using the OCU-125S, all 5.25" rewritable optical drives attach easily to any computer with SCSI support, including the Silicon Graphics platform.

Operating system support includes DOS, Netware, OS/2, Ultrix, virtually all versions of UNIX and VMS, plus many more. With the OCU-125S, system specific software is not required. Optical subsystems operate using standard operating system commands providing ease of installation and operation. The performance features of the OCU-125S include 256K cache RAM size for enhanced performance, battery backed-up cache, data "read ahead" feature, bootable device under DOS and UNIX and unmatched reading and writing speed through double-cache buffering.

For more information, contact: Jennifer Goodnight, Ten X Technology, Inc., 4807 Spicewood Springs Road, Bldg. 3, Suite 3200, Austin, TX 78759, (512) 346-8360 or fax (512) 346-9580.



SILMA Demonstrates Robotic Software Solutions

SILMA demonstrated two new 3D graphic software packages for Computer Simulated Manufacturing professionals at AUTOFACT '91. The packages are the CimStation Spot Welding and CimStation Painting Application Solution. The software is available on UNIX workstations and features direct interfaces to a variety of CAD Packages.

CimStation Spot Welding Application Solution reduces the amount of time involved in programming a spot weld application, and provides customized tools that allow manufacturers to achieve a superior weld while optimizing cycle time. Programs created using the Application Package can be automatically translated into the native language of the robot. The Spot Welding Application Solution allows manufacturers to concentrate on the quality of the weld rather than the process involved in programming a robot. The software automatically generates weld points, and includes tools which ensure a collision free weld path within the work envelope of the designated robot. In addition, the Application Solution can identify which weld guns from a manufacturer's library are capable of a particular task. If a gun suited for the task does not exist, CimStation will assist in designing the appropriate tool.

The CimStation Painting Application Solution automatically generates robot painting programs that can be translated into the native language of the robot at the click of a button. It provides a variety of analysis tools that take the guesswork out of the painting process. The software cuts programming time and can also be applied to other coating applications such as paint stripping and foam or coat spraying. The menu driven programming environment is easy to use and allows users to compute, analyze and verify paint coverage automatically.

For more information, contact: Lisa Rendleman, SILMA Inc., 1601 Saratoga-Sunnyvale Road, Cupertino, CA 95014, (408) 725-8908 or fax (408) 725-8955.

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Mastering IRIX 4.5 days	Mar 16, 1992 Apr 6, 1992 May 4, 1992 Jun 8, 1992 Jun 22, 1992	Mar 2, 1992 May 4, 1992	Apr 27, 1992 Jun 8, 1992
System Administration 4.5 days	Mar 23, 1992 Apr 13, 1992 May 11, 1992 Jun 29, 1992	Mar 9, 1992 June 1, 1992	May 4, 1992 Jun 15, 1992
Network Administration 4.5 days	Apr 27, 1992	Mar 16, 1992 Jun 8, 1992	Jun 22, 1992
System Maintenance Power Series 10.0 days	Mar 23, 1992 Jun 15, 1992	May 11, 1992	N/A
Advanced System Administration 4.5 days	Jun 8, 1992	N/A	N/A

KEY: WEC—Western Education Center, Mountain View, CA.

EEC—Eastern Education Center, SGI Federal, Bethesda, MD.

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